Cush Wind Farm

Environmental Impact Assessment Report

Annex 6.1: Geotechnical & Peat Stability Report

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GEOTECHNICAL & PEAT STABILITY REPORT

CUSH WIND FARM

Prepared for:

Cush Wind Limited

Date: **July 2023**

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GEOTECHNICAL & PEAT STABILITY ASSESSMENT REPORT
CUSH WIND FARM

REVISION CONTROL TABLE, CLIENT, KEYWORDS AND ABSTRACT

User is responsible for Checking the Revision Status of This Document

Rev. No.	Description of Changes	Prepared by:	Checked by:	Approved by:	Date:
0	Draft for Comment	EA/AMW	IH	TC	17/11/2022
01	For Client Review	EA/AMW/NSC	IH	TC	02/12/2022
02	Final	EA/MG/NSC	IH	TC	03/05/2023
03	Reissue Following Design Changes	EA/NSC	IH	TC	25/07/2023

Client: Cush Wind Limited

Keywords: Geotechnical, Peat Stability, Peat Failure, Risk Assessment

Abstract: Fehily Timoney and Company (FT) were engaged by Cush Wind Limited to undertake a geotechnical assessment of the proposed Cush wind farm site with respect to peat stability. As part of the geotechnical assessment of the proposed development, FT completed a walkover survey at the site. The findings of the geotechnical and peat stability assessment showed that the site has an acceptable margin of safety and is suitable for the proposed wind farm development.

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1. NON-TECHNCIAL SUMMARY

Fehily Timoney and Company (FT) was engaged by Cush Wind Limited to undertake a geotechnical and peat stability assessment of the proposed Cush wind farm site. In accordance with planning guidelines compiled by the Department of the Housing, Planning and Local Government (Draft Revised Wind Energy Development Guidelines, DoHPLG, 2019), where peat >0.5m in thickness is present on a proposed wind farm development, a peat stability assessment is required.

A site walkover, including intrusive peat depth probing, desk study, stability analysis and risk assessment was carried out to assess the susceptibility of the site to peat failure following the principles in Peat Landslide Hazard and Risk Assessments: Best Practice Guide for Proposed Electricity Generation Developments (PLHRAG, Scottish Government, 2017).

The findings, which involved analysis of approximately 170 locations, show that the site has an acceptable margin of safety and is suitable for the proposed wind farm project. The findings include recommendations and control measures for construction work in peat lands to ensure that all works adhere to an acceptable standard of safety.

The proposed wind farm comprises 8 no. wind turbines and associated infrastructure.

The site is relatively flat lying with drainage channels running typically northeast to southwest. The land uses and types within the proposed development site are a mixture of agricultural fields, mature forestry, bare cutover and cutaway peat and re-vegetation of bare peat.

Peat depth recorded during the site walkover and from the ground investigation ranged from 0.1 to 5.0m with an average peat depth of 2.1m. Approximately 90 percent of peat depth probes recorded peat depths of less than 4.0m. A number of localised readings were recorded where peat depths were 4.0 to 5.0m.

Hydro-Environmental Services (HES) carried out trial pitting and soil augers at each turbine location.

Slope inclinations at the main infrastructure locations range from 2 to 6 degrees. The flat topography/nature of the terrain on site reflects the low risk of peat failure.

The purpose of the stability analysis was to determine the stability i.e. Factor of Safety (FoS), of the peat slopes. The FoS provides a direct measure of the degree of stability of a peat slope. A FoS of less than 1.0 indicates that a slope is unstable; a FoS of greater than 1.0 indicates a stable slope. An acceptable FoS for slopes is generally taken as a minimum of 1.3. The stability analysis for this project, which analysed the turbine locations, access roads and 110kv Tail Fed Substation, ESB Compound and Electrical Control Room, resulted in FoS above the minimum acceptable value of 1.3 and hence the site has a satisfactory margin of safety.

The risk assessment uses the results of the stability analysis in combination with qualitative factors, which cannot be reasonably included in a stability calculation but nevertheless may affect the occurrence of peat instability, to assess the risk of peat failure at the site. The results of the risk assessment are given in Appendix B. A construction buffer zone plan based on qualitative factors identified during the site walkover is included as Figure 4.2.

The findings of the peat assessment (which combines the FOS and the risk assessment), which involved analysis of 170 no. locations , showed that the proposed development areas have an acceptable margin of safety and that the site is suitable for the proposed wind farm development. Notwithstanding the above, the management of peat stability and appropriate construction practices will be inherent in the construction phase of the wind farm to ensure peat failures do not occur on site.

In summary, the Cush wind farm site has an acceptable margin of safety and is considered to be at low risk of peat failure.

2. INTRODUCTION

2.1 Fehily Timoney and Company

Fehily Timoney and Company (FT) is an Irish engineering, environmental science and planning consultancy with offices in Cork, Dublin and Carlow. The practice was established in 1990 and currently has 100 members of staff, including engineers, scientists, planners and technical support staff. FT deliver projects in Ireland and internationally in our core competency areas of Waste Management, Environment and Energy, Civils Infrastructure, Planning and GIS and Data Management.

FT have been involved in over 100 wind farm developments in both Ireland and the UK at various stages of development i.e. preliminary feasibility, planning, design, construction and operational stage and have established themselves as one of the leading engineering consultancies in peat stability assessment, geohazard mapping in peat land areas, investigation of peat failures and site assessment of peat.

2.2 Project Description

FT was engaged in August 2022 by Cush Wind Limited to undertake a geotechnical & peat stability assessment of the proposed Cush wind farm site.

The proposed Cush wind farm is located approximately 5km north of Birr, Co. Offaly.

The Cush wind farm site comprises areas of milled peat, forestry and agricultural fields. The surrounding landscape is predominately flat with land-use comprising forestry, agricultural land and cutaway peatland.

The development comprises the following:

1. 8 no. wind turbines and all associated hard-standing areas;
2. 1 no. 110kv Tail Fed Substation, ESB Compound and Electrical Control Room;
3. Provision of new site access roads and associated drainage;
4. All works associated with the connection of the proposed wind farm to the national electricity grid;
5. 1 no. permanent meteorological mast with a height of 30m;
6. 2 no. construction compounds;
7. New access junctions, improvements and temporary modifications to existing public road infrastructure to facilitate delivery of abnormal loads and construction access;
8. All associated site development works.

The peat depth data was recorded by FT during the site walkover from the 26th to the 28th September 2022 and has been used in the assessment of peat stability for the proposed wind farm site.

2.3 Peat Stability Assessment Methodology

FT undertook the assessment following the principles in Peat Landslide Hazard and Risk Assessments: Best Practice Guide for Proposed Electricity Generation Developments (2nd edition, PLHRAG, 2017). The Peat Landslide Hazard and Risk Assessment Guide (PLHRAG) is used in this report as it provides best practice methods to identify, mitigate and manage peat slide hazards and associated risks in respect of consent applications for electricity generation projects.

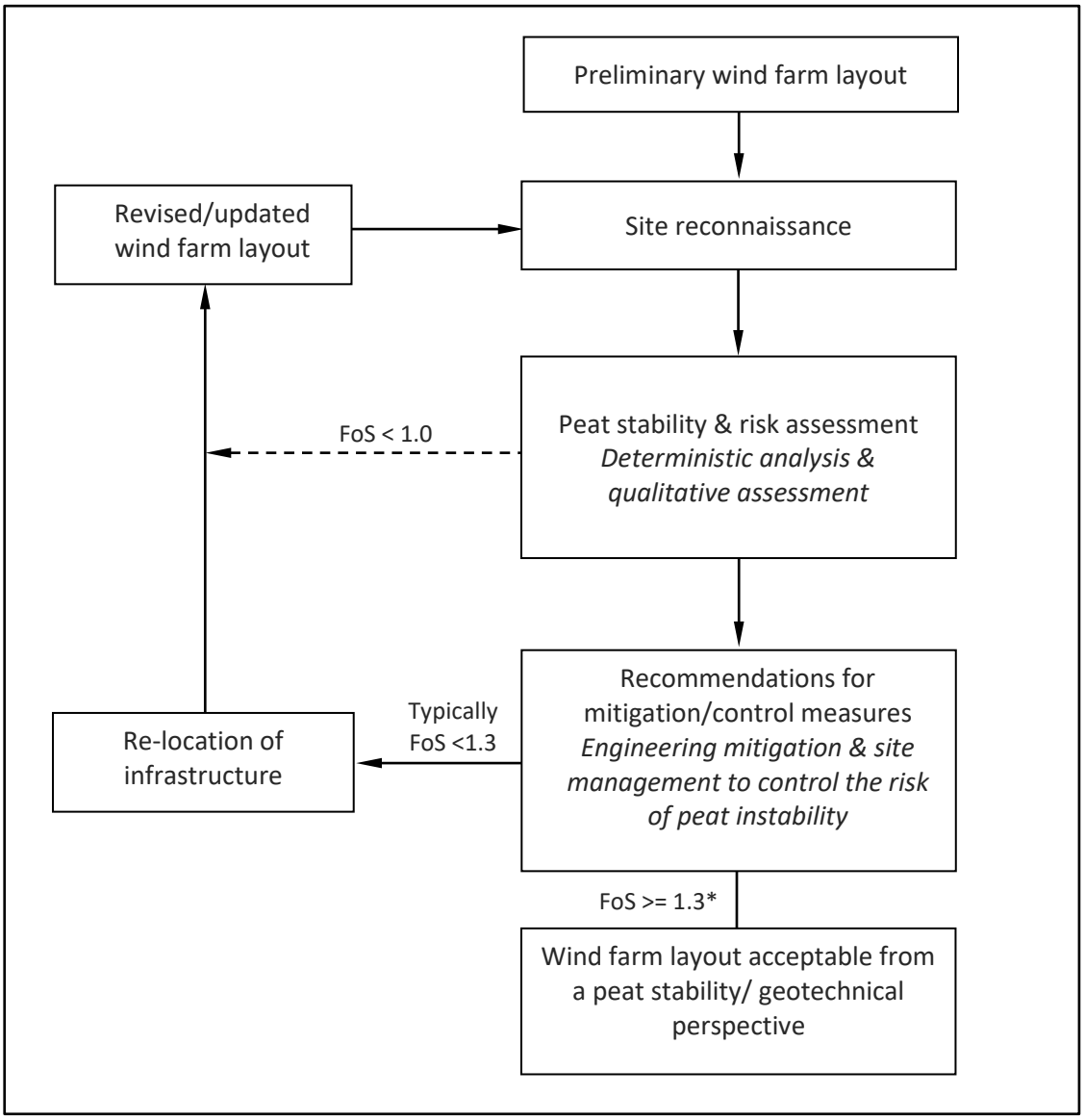
The best practice guide was produced following peat failures in the Shetland Islands, Scotland in September 2003 but more pertinently following the peat failure in October 2003, during the construction of a wind farm at Derrybrien, County Galway, Ireland.

A constraints study was initially undertaken by the Environmental, Hydrogeological and Ecological members of the design team to determine the developable area on the site, prior to the site reconnaissance by engineering geologists/geotechnical engineers from FT. The extent and depth of ground investigation and peat stability analysis by FT have been undertaken in accordance with guidance within Eurocode 7 and PLHRAG, 2017, to investigate peat slopes that have the potential to impact on the proposed development, as applicable. Sufficient peat depth data has been recorded during the site walkovers to enable the characterisation of the peat depth across the site, with additional detail at infrastructure locations by both HES and FT. The peat stability assessment is undertaken within the proposed development to identify peat slope at risk from the proposed development, and to identify peat slopes that may pose a risk to the proposed development.

The geotechnical and peat stability assessment at the site included the following activities:

1. Desk study
2. Site reconnaissance including shear strength and peat depth measurements undertaken following initial constraints study (by design team) to determine the proposed construction envelope within the site.
3. Peat stability assessment of the peat slopes on site using a deterministic and qualitative approach.
4. Peat contour depth plan – compiled based on the peat depth probes carried out across the site by FT (2022).
5. Factor of safety plan – compiled for the short-term critical condition (undrained) for approximately 170 no. FoS points analysed along the proposed infrastructure envelope on site.
6. Construction buffer zone plan – identifies areas with an elevated or higher construction risk where mitigation/control measures will need to be implemented during construction to minimise the potential risks and ensure they are kept within an acceptable range.
7. A peat stability risk register was compiled to assess the potential design/construction risks at the infrastructure locations and determine adequate mitigation/control measures for each location to minimise the potential risks and ensure they are kept within an acceptable range, where necessary
8. Preliminary assessment of foundation type for turbines.
9. Commentary of founding details for other infrastructure elements such as access roads, crane hardstands, 110kv Tail Fed Substation, ESB Compound and Electrical Control Room & construction compound platforms and met mast foundation.

A flow diagram showing the general methodology for peat stability assessment is shown in Figure 2.1. The methodology illustrates the optimisation of the wind farm layout based on the findings from the site reconnaissance and stability analysis and subsequent feedback.



*An FoS of between 1.0 and 1.3 does not mean that a failure will occur, but that the area requires attention. Mitigation measures can be provided for areas with an FoS of between 1.0 and 1.3 to reduce the risk of failure.

Figure 2-1: Methodology for Peat Stability Assessment

As for all construction projects, a detailed engineering construction design must be carried out by the appointed construction stage designer prior to any construction work commencing on site. This must take account of the consented project details and any conditions imposed by that consent. This must include a detailed peat stability assessment to account for any changes in the environment which may have occurred in the time leading up to the commencement of construction and a peat and spoil management plan to allow for the most appropriate geotechnical and environmental led solutions to be developed for the management of peat and spoil.

2.4 Peat Failure Definition

Peat failure in this report refers to a significant mass movement of a body of peat that would have an adverse impact on the proposed wind farm development and the surrounding environment. Peat failure excludes localised movement of peat that would occur below an access road, creep movement or erosion type events.

The potential for peat failure at this site is examined with respect to wind farm construction and associated activity.

2.5 Main Approaches to Assessing Peat Stability

The main approaches for assessing peat stability for wind farm developments include the following:

1. Geomorphological;
2. Qualitative (judgement);
3. Index/Probabilistic (probability);
4. Deterministic (factor of safety).

Approaches (1) to (3) listed above are considered subjective and do not provide a definitive indication of stability; in addition, a high level of judgement/experience is required which makes it difficult to relate the findings to real conditions. FT apply a more objective approach, the deterministic approach (as discussed in Section 2.6).

As part of FT's deterministic approach, a qualitative risk assessment is also carried out taking into account qualitative factors, which cannot necessarily be quantified, such as the presence of mechanically cut peat, quaking peat, bog pools, sub peat water flow, slope characteristics and numerous other factors. The qualitative factors used in the risk assessment are compiled based on FT's experience of assessments and construction in peat land sites and peat failures throughout Ireland and the UK. FT have been involved with in excess of 100 wind farm developments across Ireland and the UK at various stages of development, from preliminary feasibility stage through planning and from scheme development at tender design and detailed design stage, through to the construction and operational stages. This approach follows the guidelines for geotechnical risk management as given in Clayton (2001), as referenced in the best practice for Peat Landslide Hazard and Risk Assessment Guide (PLHRAG, 2017), and takes into account the approach of MacCulloch (2005).

The risk assessment uses the results of the deterministic approach in combination with qualitative factors, which cannot be reasonably included in a stability calculation but nevertheless may affect the occurrence of peat instability to assess the risk of instability on a peat land site.

2.6 Peat Stability Assessment – Deterministic Approach

The peat stability assessment is carried out across a wide area of peatland to determine the stability of peat slopes and to identify areas of peatland that are suitable for development; this allows the layout of infrastructure on a particular wind farm site to be optimised. The assessment provides a numerical value (factor of safety) of the stability of individual parcels of peatland. The findings of the assessment discriminate between areas of stable and unstable peat, and areas of marginal stability where restrictions may apply. This allows for the identification of the most suitable locations for turbines, access roads and infrastructure.

A deterministic assessment requires geotechnical information and site characteristics which are obtained from desk study and site walkover, e.g. properties of peat/soil/rock, slope geometry, depth of peat, underlying strata, groundwater, etc. An adverse combination of the factors listed above could potentially result in instability. Using the information above, a factor of safety is calculated for the stability of individual parcels of peatland on a site (as discussed in Section 7).

The factor of safety is a measure of the stability of a particular slope. For any slope, the degree of stability depends on the balance of forces between the weight of the soil/peat working downslope (destabilising force) and the inherent strength of the peat/soil (shear resistance) to resist the downslope weight, see Figure 2.2.

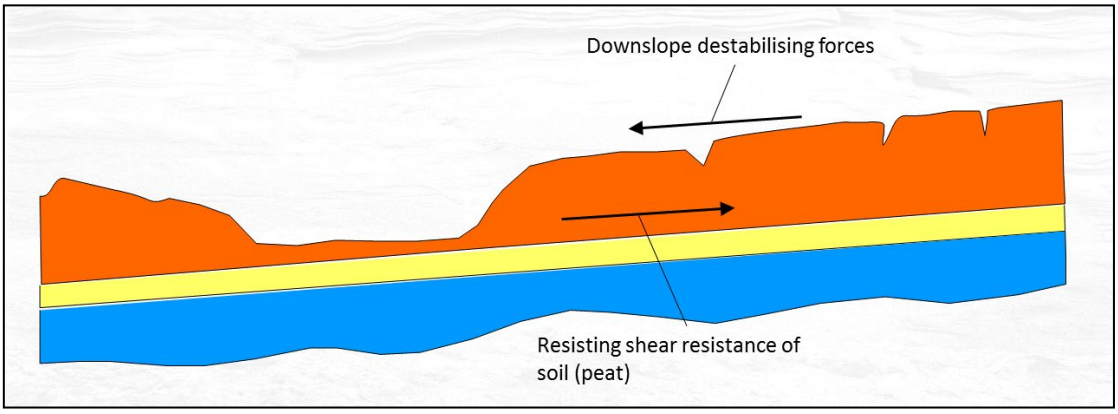


Figure 2-2: Peat Slope Showing Balance of Forces to Maintain Stability

The factor of safety provides a direct measure of the degree of stability of a slope and is the ratio of the shear resistance over the downslope destabilising force. Provided the available shear resistance is greater than the downslope destabilising force then the factor of safety will be greater than 1.0 and the slope will remain stable. If the factor of safety is less than 1.0 the slope is unstable and liable to fail. The acceptable range for factor of safety is typically from 1.3 to 1.4.

2.7 Applicability of the Factor of Safety (Deterministic) Approach for Peat Slopes

The factor of safety approach is a standard engineering approach in assessing slopes which is applied to many engineering materials, such as peat, soil, rock, etc.

The factor of safety approach is included in the Peat Landslide Hazard and Risk Assessments Best Practice Guide for Proposed Electricity Generation Developments (PLHRAG, 2017); see Section 5.3.1 of the guide. This guide provides best practice methods to identify, mitigate and manage peat slide hazards and associated risks in respect of consent applications for electricity generation projects.

Furthermore, the best practice guide notes that the results from the factor of safety approach 'has provided the most informative results' with respect to analysing peat stability (Section 5.3.1 of the guide).

The factor of safety approach in this report includes undrained (short-term stability) and drained (long-term stability) analyses. The undrained condition is the critical condition for the development. The purpose of the drained analysis is to identify the relative susceptibility of rainfall-induced failures at the site.

Notwithstanding the above, the stability analysis used by FT in this report also includes qualitative factors to determine the potential for peat stability i.e. the analysis used does not solely rely on the factor of safety approach.

The deterministic analysis is considered an acceptable engineering design approach. This concurs with the best practice guide referenced above.

2.8 Assessment of Intense Rainfall and Extreme Dry Events on the Peat Slope

The deterministic approach carried out by FT examines intense rainfall and extreme dry events. The deterministic approach includes an undrained (short-term stability) and drained (long-term stability) analysis to assess the factor of safety for the peat slopes against a peat failure.

The drained loading condition applies in the long-term. This condition examines the effect of the change in groundwater level as a result of rainfall on the existing stability of the natural peat slopes. For the drained analysis the level of the water table above the failure surface is required to calculate the factor of safety for the peat slope.

In order to represent varying water levels within the peat slopes, a sensitivity analysis is carried out which assesses varying water level in the peat slopes i.e. water levels ranging from 0 to 100% of the peat depth is conducted, where 0% equates to the peat been completely dry and 100% equates to the peat being fully saturated.

By carrying out such a sensitivity analysis with varying water level in the peat slopes, the effects of intense rainfall and extreme dry events are considered and analysed. The results of which are presented in Section 7 of this report.

3. DESK STUDY

3.1 Desk Study

The main relevant sources of interest with respect to the site include:

- Geological plans and Geological Survey of Ireland database;
- Ordnance survey plans;
- Literature review of peat failures.

The Geological Survey of Ireland (GSI, 1999) geological plans for the site were used to verify the soil and bedrock conditions.

The Ordnance Survey plans were reviewed to determine if any notable features or areas of particular interest (from a geotechnical point of view) are present on the site.

The desk study also includes a review of both published literature and GSI online dataset viewer (GSI, 2022) on peat failures/landslides in the vicinity of the site.

3.2 Soils, Subsoil & Bedrock

A review of the Geological Survey of Ireland online database and published documents from GSI was carried out.

The GSI subsoils maps indicates that the site is underlain by a combination of predominantly cut over raised peat with small pockets of till derived from limestones and gravels derived from limestone.

In relation to bedrock, the site location and surrounding area is underlain by the Waulsortian Limestone Formation. This formation comprises a massive, unbedded lime-mudstone. The north-eastern corner of the site is underlain by the Visean Limestones, and the south-western area of the site is underlain by the Ballysteen Formation which comprises dark muddy limestone and shale.

Loughnane Concrete Ltd. is an operational quarry located approximately 1km south of the site. This quarry produces concrete, sand, gravel, aggregate and road surfacing materials. Smyth's Sand and Gravel Ltd. is another quarry located approximately 10km south-west of the site and produces ready-mix concrete, liquid floor screed, precast products and blocks.

No karst features were identified on the survey area. The nearest karst feature was recorded 5km to the west of the site and is described as a spring.

No geological heritage sites are noted within the site boundary, however, the Kilcormac Esker is located running along the eastern boundary of the site.

3.3 Previous Failures

There are no recorded peat failures within the Cush wind farm site (GSI, 2022). The nearest recorded failure is located at Lisheen Bog, approximately 6km south of the study area. This failure occurred in the early 20th century.

The landslide susceptibility the site was classified by the GSI (2022) as low susceptibility, which is expected given the flat terrain present.

The presence, or otherwise, of relict peat failures or clustering of relict failures within an area is an indicator that particular site conditions exist that pre-dispose a site to failure or not as the case may be. Hence based on the historical data reviewed and the terrain and ground conditions present on site it can be concluded that site conditions in the area of the Cush site have a limited potential of peat failure.

4. FINDINGS OF SITE RECONNAISSANCE

4.1 Site Reconnaissance

As part of the assessment of potential peat failure at the proposed site, FT carried out a site reconnaissance in conjunction with the desk study review described in Section 3. This comprised walkover inspections of the site with recording of salient geomorphological features with respect to the wind farm development which included peat depth and preliminary assessment of peat strength. General photographs of the site are included at the end of the main text.

The following salient geomorphological features were considered:

- Active, incipient or relict instability (where present) within the peat deposits;
- Presence of shallow valley or drainage line;
- Wet areas;
- Any change in vegetation;
- Peat depth;
- Slope inclination and break in slope.

The survey covered the proposed locations for the turbine bases and associated infrastructure.

The method adopted for carrying out the site reconnaissance relied on experienced practitioners carrying out a visual assessment of the site supplemented with measurement of slope inclinations.

4.2 Findings of Site Reconnaissance

The site reconnaissance comprised a walkover inspection of the site from the 26th to the 28th September 2022. Weather conditions for the site visit were overcast and misty.

The findings from the site walkover have been used to optimise the layout of the infrastructure on site.

The main findings of the site walkover of the wind farm site are as follows:

1. The site is typically covered in a layer of peat and is relatively flat. Peat depths vary across the site depending on mainly topography. Bare cutover and cutaway peat and re-vegetation of bare peat are present across the site (see Appendix A).
2. A total of approximately 170 no. peat depth probes were carried out on site. Peat depths recorded from peat probing across the site ranged from 0.1 to 5.0m with an average depth of 2.1m (Figure 4-1). Approximately 90 percent of peat depth probes recorded peat depths of less than 4.0m. A number of localised readings were recorded where peat depths were between 4.0 and 5.0m.
3. The peat depths recorded at the turbine locations varied from 0.1 to 3.7m with an average depth of 2.2m.
4. With respect to the new proposed access roads, peat depths are typically less than 3.0m with localised depths of up to 5.0m recorded.

5. The access roads for the wind farm upgrade comprise of the upgrade of existing access roads and the construction of new proposed access roads. The construction of new proposed access roads will be carried out using either a floating or an excavate & replace construction technique which involves the removal of peat or soft ground where encountered, and replacement with granular fill.
6. Slope angles at the turbine locations ranged from 2 to 6 degrees. These slope angle readings were obtained using a combination of readings taken during the site reconnaissance by FT using handheld equipment, such as the Silva Clino Master which has an accuracy of +/- 0.25 degrees and from contour survey plans for the site.
7. The slope angle quoted typically reflects the slope within the footprint of each infrastructure location. The flat topography/nature of the terrain on site highlights the low risk of peat failure.
8. No evidence of past failures or any significant signs of peat instability were noted on site.
9. A summary of the site walkover findings for the wind farm are as follows:

a) The site is typically covered in a layer of peat with typically flat terrain and open peatland. Peat depths recorded across the site ranged from 0.1 to 5.0m with an average depth of 2.1m.

b) The results of the peat depth probing, shear strength testing of the peat and qualitative factors identified on site have been used in the stability and risk assessments, see Sections 6, 7 and 8 of this report for details.

c) Based on the findings from the walkover survey, the proposed wind farm development is considered to have a low risk of peat failure.

In summary, based on the findings from the site reconnaissance, the proposed development footprint for the site would be considered to have a low risk of peat instability.

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Legend:

- Application Boundary
- Proposed Access Track
- Proposed Cable Route
- Proposed Turbine
- Proposed Site Compound
- Proposed 110kv Tail Fed Substation, ESB Compound and Electrical Control Room
- Proposed Spoil Deposition Area
- Proposed Forestry Felling Area

Peat Depth Legend:

- ≥ 0 < 0.5
- ≥ 0.5 < 1
- ≥ 1 < 1.5
- ≥ 1.5 < 2
- ≥ 2 < 2.5
- ≥ 2.5 < 3
- ≥ 3 < 3.5
- ≥ 3.5 < 4

T1
T2
T3
T4
T5
T6
T7
T8
Met Mast

0m 50m 100m 150m 200m 250m 300m 350m 400m 450m 500m

Scale 1:5000

PLAN

Scale 1:5000

PLAN (Access offsite to the south)

Scale 1:5000

Main site
Approx. 2.1km
Access offsite to the south

KEYPLAN

Scale 1:40000

Scale (@ A1) 1:5000

Date - 20.07.23

FIGURE 4.1 - PEAT DEPTH CONTOUR PLAN

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5. PEAT DEPTHS, STRENGTH & SLOPE AT PROPOSED INFRASTRUCTURE LOCATIONS

As part of the site walkover, peat depth, in-situ peat strength and slope angles were recorded at various locations across the site.

5.1 Peat Depth

Peat depth probes were carried out at/near to proposed turbine locations and access roads and other main infrastructure elements. At turbine locations up to 5 probes were carried out around the turbine location, and an average peat depth was calculated. Hydro-Environmental Services (HES) carried out trial pitting and soil augers at each turbine location.

5.2 Peat Strength

The strength testing was carried out in-situ using a Geonor H-60 Hand-Field Vane Tester. From FT's experience hand vanes give indicative results for in-situ strength of peat and would be considered best practice for the field assessment of peat strength.

5.3 Slope Angle

The slope angles at each of the main infrastructure locations were obtained using a combination of readings taken during the site reconnaissance by FT using handheld equipment, such as the Silva Clino Master and from contour survey plans for site.

The slope angle quoted typically reflects the slope within the footprint of each infrastructure location. It should be noted that slope angles derived from contour survey plans would be considered approximate, as such surveys are dependent on the density of survey data and do not always reflect local variations in ground topography. Slope angles recorded during the site reconnaissance by FT using handheld equipment would generally be deemed more accurate and representative of local topography.

5.4 Summary of Findings

Based on the peat depths recorded across the site by FT and HES, the peat varied in depth from 0.1 to 5.0m with an average depth of 2.1m. All peat depth probes carried out on site have been utilised to produce a peat depth contour plan for the site (Figure 4.1).

A summary of the peat depths at the proposed infrastructure locations is given in Table 5.1. The data presented in Table 5.1 is used in the peat stability assessment of the site.

Table 5-1: Peat Depth & Slope Angle at Proposed Infrastructure Locations

Turbine	Easting	Northing	Peat Depth Range (m) [1]	Average Peat Depth (m)	Slope Angle (°) [2]
T01	606797	710446	1.5 – 3.3	2.4	2
T02	606312	709829	0.5 - 4	2.3	2
T03	607351	710752	2 – 3.8	2.9	2
T04	607059	710032	1 - 4.3	2.7	2
T05	607922	710465	1.4 - 2.1	1.8	2
T06	607844	709967	2 – 2.5	2.3	3
T07	608285	709734	0.1	0.1	3
T08	608427	710194	0.1 – 0.4	0.3	6
Proposed 110kv Tail Fed Substation, ESB Compound and Electrical Control Room	604937	708195	No Peat	No Peat	2
Construction Compound	606271	709149	No Peat	No Peat	4
Met Mast	608482	709505	0.3 – 0.5	0.4	3

Note (1) Based on probe results from the site walkovers and from trial pits and soil augers carried out by HES. The range of peat depths for the infrastructure locations are typically based on a 10m grid carried out around the infrastructure element, where accessible.

Note (2) The slope angles at each of the main infrastructure locations were obtained using a combination of readings taken during the site reconnaissance by FT using handheld equipment, such as the Silva Clino Master (which has an accuracy of +/- 0.25 degrees) and from contour survey plans for site. The slope angle quoted typically reflects the slope within the footprint of each infrastructure location.

Note (3) The data presented in the Table above is used in the peat stability assessment of the site.

Hydro-Environmental Services (HES) carried out trial pitting and soil augers at each turbine location. It was found that there is a soft lacustrine marl present beneath the peat, across the site. Based on the findings from the trial pitting and the soil augers it is likely that the peat probes carried out extended into this lacustrine marl layer. The peat stability assessment has taken a conservative approach and based the assessment on the peat probe depths.

In addition to probing, in-situ shear vane testing was carried out as part of the ground investigation. Strength testing was carried out at selected locations across the site to provide representative coverage of indicative peat strengths. The results of the vane testing with depth are presented in Figure 5.1.

The hand vane results indicate undrained shear strengths in the range 18 to 65kPa, with an average value of about 44kPa. The strengths recorded would be typical of well drained peat as is present on the Cush site.

Peat strength at sites of known peat failures (assuming undrained loading failure) are generally very low, for example the undrained shear strength at the Derrybrien failure (AGEC, 2004) as derived from back-analysis, was estimated at 2.5kPa. The recorded undrained strength at Cush is significantly greater than the lower bound values for Derrybrien indicating that there is no close correlation to the peat conditions at the Derrybrien site and that there is significantly less likelihood of failure on the Cush site.

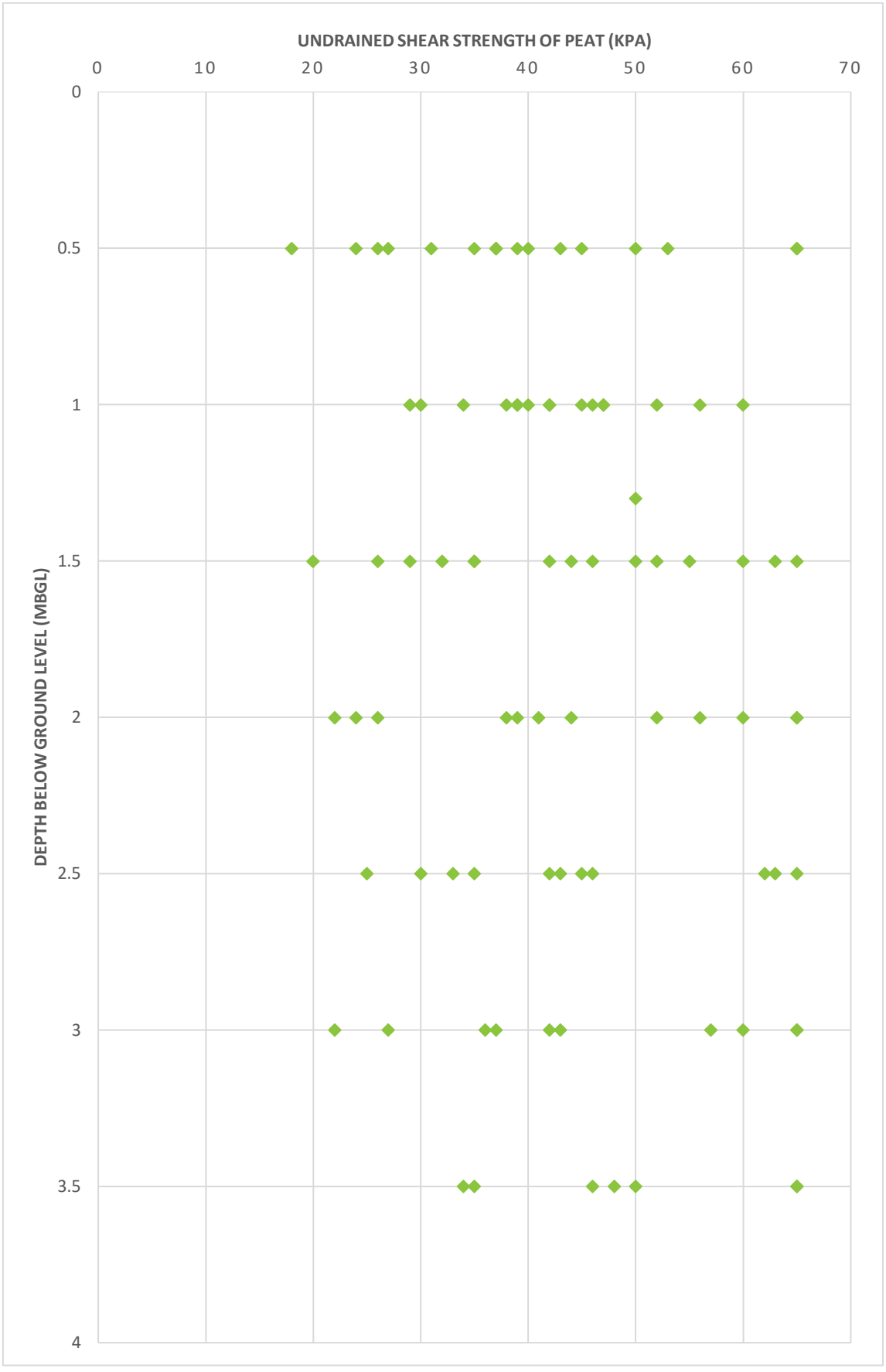

Figure 5-1: Undrained Shear Strength (c_u) Profile for Peat with Depth

6. PEAT STABILITY ASSESSMENTS

The peat stability assessment includes an assessment of the stability of the natural peat slopes for individual parcels across the site including at the turbine locations and along the proposed access roads. The assessment also analyses the stability of the natural peat slopes with a surcharge loading of 10kPa, equivalent to placing 1m of stockpiled peat on the surface of the peat slope.

6.1 Methodology for Peat Stability Assessment

Stability of a peat slope is dependent on several factors working in combination. The main factors that influence peat stability are slope angle, shear strength of peat, depth of peat, pore water pressure and loading conditions.

An adverse combination of factors could potentially result in peat sliding. An adverse condition of one of the above-mentioned factors alone is unlikely to result in peat failure. The infinite slope model (Skempton and DeLory, 1957) is used to combine these factors to determine a factor of safety for peat sliding. This model is based on a translational slide, which is a reasonable representation of the dominant mode of movement for peat failures.

To assess the factor of safety for a peat slide, an undrained (short-term stability) and drained (long-term stability) analysis has been undertaken to determine the stability of the peat slopes on site.

1. The undrained loading condition applies in the short-term during construction and until construction induced pore water pressures dissipate.
2. The drained loading condition applies in the long-term. The condition examines the effect of the change in groundwater level as a result of rainfall on the existing stability of the natural peat slopes.

Undrained shear strength values (cu) for peat are used for the total stress analysis. Based on the findings of the 2003 Derrybrien failure and other failures in peat, undrained loading during construction was found to be the critical failure mechanism.

A drained analysis requires effective cohesion (c') and effective friction angle (ø') values for the calculations. These values can be difficult to obtain because of disturbance experienced when sampling peat and the difficulties in interpreting test results due to the excessive strain induced within the peat. To determine suitable drained strength values a review of published information on peat was carried out. Table 6.1 shows a summary of the published information on peat together with drained strength values.

From Table 6.1 the values for c' ranged from 1.1 to 8.74kPa and ø' ranged from 21.6 to 43°. The average c' and ø' values are 4.5kPa and 30° respectively. Based on the above, it was considered to adopt a conservative approach and to use design values below the averages. For design the following general drained strength values have been used for the site:

c' = 4kPa

ø' = 25°

Table 6-1: List of Effective Cohesion and Friction Angle Values for Peat

Reference	Cohesion, c' (kPa)	Friction Angle, ø' (degs)	Testing Apparatus/ Comments
Hanrahan et al (1967)	5 to 7	36 to 43	From triaxial apparatus
Rowe and Mylleville (1996)	2.5	28	From simple shear apparatus
Landva (1980)	2 to 4	27.1 to 32.5	Mainly ring shear apparatus for normal stress greater than 13kPa
	5 to 6	-	At zero normal stress
Carling (1986)	6.5	0	-
Farrell and Hebib (1998)	0	38	From ring shear and shear box apparatus. Results are not considered representative.
	0.61	31	From direct simple shear (DSS) apparatus. Result considered too low therefore DSS not considered appropriate
Rowe, Maclean and Soderman (1984)	1.1	26	From simple shear apparatus
	3	27	From DSS apparatus
McGreever and Farrell (1988)	6	38	From triaxial apparatus using soil with 20% organic content
	6	31	From shear box apparatus using soil with 20% organic content
Hungr and Evans (1985)	3.3	-	Back-analysed from failure
Dykes and Kirk (2006)	3.2	30.4	Test within acrotelm
Dykes and Kirk (2006)	4	28.8	Test within catotelm
Warburton et al (2003)	5	23.9	Test in basal peat
Warburton et al (2003)	8.74	21.6	Test using fibrous peat
Hendry et al (2012)	0	31	Remoulded test specimen
Komatsu et al (2011)	8	34	Remoulded test specimen
Zwanenburg et al (2012)	2.3	32.3	From DSS apparatus
Den Haan & Grognet (2014)	-	37.4	From large DSS apparatus
O'Kelly & Zhang (2013)	0	28.9 to 30.3	Tests carried out on reconstituted, undisturbed and blended peat samples.

6.2 Analysis to Determine Factor of Safety (Deterministic Approach)

The purpose of the analysis was to determine the Factor of Safety (FoS) of the peat slopes using infinite slope analysis. The analysis was carried out at the turbine locations, along the proposed access roads and at various locations across the site.

The FoS provides a direct measure of the degree of stability of the slope. A FoS of less than unity (1.0) indicates that a slope is unstable, a FoS of greater than unity indicates a stable slope.

The acceptable safe range for FoS typically ranges from 1.3 to 1.4. The previous code of practice for earthworks BS 6031:1981 (BSI, 1981), provided advice on design of earthworks slopes. It stated that for a first-time failure with a good standard of site investigation the design FoS should be greater than 1.3.

As a general guide the FoS limits for peat slopes in this report are summarised in Table 6.2.

Table 6-2: Factor of Safety Limits for Slopes

Factor of Safety (FoS)	Degree of Stability
Less than 1.0	Unstable (red)
Between 1.0 and 1.3	Marginally stable (yellow)
1.3 or greater	Acceptable (green)

Eurocode 7 (EC7) (IS EN 1997-1:2005) now serves as the reference document and the basis for design geotechnical engineering works. The design philosophy used in EC7 applies partial factors to soil parameters, actions and resistances. Unlike the traditional approach, EC7 does not provide a direct measure of stability since global Factors of Safety are not used.

As such, and in order to provide a direct measure of the level of safety on a site, EC7 partial factors have not been used in this stability assessment. The results are given in terms of FoS.

A lower bound undrained shear strength, c_u for the peat of 8kPa was selected for the assessment based on the cu values recorded at the site. It should be noted that a c_u of 8kPa for the peat is considered a conservative value for the analysis and is not representative of all peat present across the site. In reality the peat generally has a higher undrained strength.

The formula used to determine the factor of safety for the undrained condition in the peat (Bromhead, 1986) is as follows:

$$F = \frac{c_u}{\gamma z \sin\alpha \cos\alpha}$$

Where:

F = Factor of Safety

c_u = Undrained strength

γ = Bulk unit weight of material

z = Depth to failure plane assumed as depth of peat

α = Slope angle

The formula used to determine the factor of safety for the drained condition in the peat (Bromhead, 1986) is as follows:

$$F = \frac{c' + (\gamma z - \gamma_w h_w)\cos^2 \alpha \tan \phi'}{\gamma z \sin \alpha \cos \alpha}$$

Where:

F = Factor of Safety

c' = Effective cohesion

γ = Bulk unit weight of material

z = Depth to failure plane assumed as depth of peat

γ_w = Unit weight of water

h_w = Height of water table above failure plane

α = Slope angle

ϕ' = Effective friction angle

For the drained analysis the level of the water table above the failure surface is required to calculate the factor of safety for the slope. Since the water level in blanket peat can be variable and can be recharged by rainfall, it is not feasible to establish its precise location throughout the site. Therefore, a sensitivity analysis using water level ranging between 0% and 100% of the peat depth was conducted, where 0% equates to the peat being completely dry and 100% equates to the peat been fully saturated.

The following general assumptions were used in the analysis of peat slopes at each location:

1. Peat depths are based on the maximum peat depth recorded at each location from the walkover surveys.
2. The slope angles used in the peat stability assessment were obtained using a combination of readings taken during the site reconnaissance by FT using handheld equipment and from contour survey plans for site. It should be noted that slope angles derived from contour survey plans would be considered approximate, as such surveys are dependent on the density of survey data and do not always reflect local variations in ground topography.
3. Slope angle at base of sliding assumed to be parallel to ground surface.
4. A lower bound undrained shear strength, c_u for the peat of 8kPa was selected for the assessment. The lowest recorded value on the Cush wind farm site during the site walkover was 18kPa. It should be noted that a c_u of 8kPa for the peat is considered a conservative value for the analysis and is not representative of all peat present across the site. In reality, the peat has a significantly higher undrained strength as a result of the extensive drainage & extraction works which have been carried out on site.

For the stability analysis two load conditions were examined, namely:

Condition (1): no surcharge loading;

Condition (2): surcharge of 10 kPa, equivalent to 1m of stockpiled peat assumed as a worst case.

6.3 Results of Analysis

6.3.1 Undrained Analysis for the Peat

The results of the undrained analysis for the natural peat slopes are presented in Appendix C. The undrained analysis for load condition 2 is considered the most critical load case as most peat failures occur in the short term upon loading of the peat surface. The results from the main infrastructure locations are summarised in Table 6.3.

The calculated FoS for load condition 1 is in excess of 1.30 for each of the locations (approx. 170 no. locations) analysed with a range of FoS of 1.92 to 172.03, indicating a low risk of peat instability.

The calculated FoS for load condition 2 is in excess of 1.30 for each of the locations (approx. 170 no. locations) analysed with a range of FoS of 1.57 to 17.20, indicating a low risk of peat instability.

Table 6-3: Factor of Safety Results for Infrastructure Locations (Undrained Condition)

Turbine No./Waypoint	Easting	Northing	Factor of Safety for Load Condition	
			Condition (1)	Condition (2)
T1	606797	710446	**5.55**	**4.20**
T2	606312	709829	**5.06**	**3.91**
T3	607351	710752	**5.06**	**3.91**
T4	607059	710032	**4.65**	**3.66**
T5	607922	710465	**14.34**	**7.82**
T6	607844	709967	**5.22**	**3.59**
T7	608285	709734	**114.80**	**10.44**
T8	608427	710194	**28.86**	**4.81**
110kv Tail Fed Substation, ESB Compound and Electrical Control Room	604937	708195	**No peat encountered**	
Construction Compound 1	606271	709149	**16.28**	**5.16**
Construction Compound 2	608374	710304	**43.11**	**7.19**
Met Mast	608482	709505	**22.96**	**7.65**
Spoil Deposition Area	606684	710675	**4.59**	**3.28**

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Legend:

- Application Boundary
- Proposed Access Track
- Proposed Cable Route
- Proposed Turbine
- Proposed Site Compound
- Proposed 110kv Tail Fed Substation, ESB Compound and Electrical Control Room
- Proposed Spoil Deposition Area
- Proposed Forestry Felling Area

Factor of Safety Legend:

- 0 < 1.0
- ≥ 1.0 < 1.3
- ≥ 1.3

Increasing Stability

No Peat Recorded At This Location

T1
T2
T3
T4
T5
T6
T7
T8
Met Mast

0m 50m 100m 150m 200m 250m 300m 350m 400m 450m 500m

Scale 1:5000

PLAN

Scale 1:5000

PLAN (Access offsite to the south)

Scale 1:5000

Main site
Approx. 2.1km
Access offsite to the south

KEYPLAN

Scale 1:40000

Scale (@ A1)
1:5000

Date - 20.07.23

FIGURE 6.1 - FACTOR OF SAFETY PLAN

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Checked - IH
Rev - C

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6.3.2 Drained Analysis for the Peat

The results of the drained analysis for the peat are presented in Appendix C. The results from the main infrastructure locations are summarised in Table 6.4. As stated previously, the drained loading condition examines the effect of rainfall and water on the existing stability of the natural peat slopes.

The calculated FoS for load condition 1 is in excess of 1.30 for each of the locations (approx. 170 no. locations) analysed with a range of FoS of 1.80 to 114.68, indicating a low risk of peat instability.

The calculated FoS for load condition 2 is in excess of 1.30 for each of the locations (approx. 170 no. locations) analysed with a range of FoS of 2.75 to 24.82, indicating a low risk of peat instability.

Table 6-4: Factor of Safety Results for Infrastructure Locations (Drained Conditions)

Turbine No./Waypoint	Easting	Northing	Factor of Safety for Load Condition	
			Condition (1)	Condition (2)
T1	606797	710446	**17.05**	**16.15**
T2	606312	709829	**16.73**	**15.96**
T3	607351	710752	**16.73**	**15.96**
T4	607059	710032	**16.45**	**15.79**
T5	607922	710465	**22.91**	**18.57**
T6	607844	709967	**12.38**	**11.29**
T7	608285	709734	**85.43**	**15.86**
T8	608427	710194	**23.68**	**7.64**
110kv Tail Fed Substation, ESB Compound and Electrical Control Room	604937	708195	**No peat encountered**	
Construction Compound 1	606271	709149	**17.53**	**10.12**
Construction Compound 2	608374	710304	**70.70**	**22.91**
Met Mast	608482	709505	**24.20**	**14.00**
Spoil Deposition Area	606684	710675	**11.96**	**11.08**

7. PEAT STABILITY RISK ASSESSMENT

A peat stability risk assessment was carried out for the main infrastructure elements at the wind farm. This approach takes into account guidelines for geotechnical/peat stability risk assessments as given in PLHRAG (2017) and MacCulloch (2005).

The risk assessment uses the results of the stability analysis (deterministic approach) in combination with qualitative factors, which cannot be reasonably included in a stability calculation but nevertheless may affect the occurrence of peat instability, to assess the risk for each infrastructure element.

For each of the main infrastructure elements, a risk rating (product of probability and impact) is calculated and rated as shown in Table 7.1. Where a subsection is rated 'Medium' or 'High', control measures are required to reduce the risk to at least a 'Low' risk rating. Where a subsection is rated 'Low' or 'Negligible', only routine control measures are required.

Table 7-1: Risk Rating Legend

17 to 25	High: avoid works in area or significant control measures required
11 to 16	Medium: notable control measures required
5 to 10	Low: only routine control measures required
1 to 4	Negligible: none or only routine control measures required

A full methodology for the peat stability risk assessment is given in Appendix D.

7.1 Summary of Risk Assessment Results

The results of the peat stability risk assessment for potential peat failure at the main infrastructure elements is presented as a Geotechnical Risk Register in Appendix B and summarised in Table 7.2.

The risk rating for each infrastructure element at the Cush wind farm is designated trivial following some mitigation/control measures being implemented. Sections of access roads to the nearest infrastructure element will be subject to the same mitigation/control measures that apply to the nearest infrastructure element.

Details of the required mitigation/control measures can be found in the Geotechnical Risk Register for each infrastructure element (Appendix B).

Table 7-2: Summary of Peat Stability Risk Register

Infrastructure	Pre- General Control Measure Implementation Risk Rating	Pre- General Control Measure Implementation Risk Rating Category	Specific Control Measures Required	Post- General Control Measure Implementation Risk Rating	Post- General Control Measure Implementation Risk Rating Category
T1	Low	5 to 10	No	Low	5 to 10
T2	Low	5 to 10	No	Negligible	1 to 4
T3	Negligible	1 to 4	No	Negligible	1 to 4
T4	Negligible	1 to 4	No	Negligible	1 to 4
T5	Low	5 to 10	No	Negligible	1 to 4
T6	Negligible	1 to 4	No	Negligible	1 to 4
T7	Negligible	1 to 4	No	Negligible	1 to 4
T8	Negligible	1 to 4	No	Negligible	1 to 4
Peat Spoil Deposition Area	Negligible	1 to 4	No	Negligible	1 to 4
110kv Tail Fed Substation, ESB Compound and Electrical Control Room	No peat recorded at location				
Met Mast	Negligible	1 to 4	No	Negligible	1 to 4
Construction Compound 1	Negligible	1 to 4	No	Negligible	1 to 4
Construction Compound 2	Negligible	1 to 4	No	Negligible	1 to 4

8. INDICTATIVE FOUNDATION TYPE AND FOUNDATION DEPTH FOR TURBINES

8.1 Summary

Based on a review of the ground investigation information for site, a preliminary assessment of the likely foundation type and founding depths for each turbine location was carried out, where possible. A summary of this assessment is provided in Table 8-1:

Table 8-1: Summary of Indicative Turbine Foundation Type and Founding Depths

Turbine No.	Turbine Foundation Type	Relevant GI	Indicative founding depth (m bgl)	Comment
T1	Gravity/Piled foundation	Peat probing/Trial Pit	>5	The site investigation works carried out indicate that either a gravity or a piled foundation may be required.
T2	Gravity/Piled foundation	Peat probing/Trial Pit	>5	The site investigation works carried out indicate that either a gravity or a piled foundation may be required.
T3	Gravity/Piled foundation	Peat probing/Trial Pit	>5	The site investigation works carried out indicate that either a gravity or a piled foundation may be required.
T4	Gravity/Piled foundation	Peat probing/Soil auger	>3	The site investigation works carried out indicate that either a gravity or a piled foundation may be required.
T5	Gravity foundation	Peat probing/Soil auger	3	The site investigation works carried out indicate that a gravity foundation may be required.
T6	Gravity/Piled foundation	Peat probing/Trial Pit	>5	The site investigation works carried out indicate that either a gravity or a piled foundation may be required.
T7	Gravity foundation	Peat probing/Trial Pit	3	The site investigation works carried out indicate that a gravity foundation may be required.
T8	Gravity foundation	Peat probing/Trial Pit	3	The site investigation works carried out indicate that a gravity foundation may be required.

It should be noted that confirmatory ground investigation should be carried out prior to construction at each turbine location in the form of a borehole with in-situ SPT testing at 1m intervals in the overburden and follow-on rotary core through bedrock to confirm the foundation types and founding stratums indicated in Table 8-1. It is likely that following the completion of further ground investigation prior to construction that a number of the turbine bases will be deemed suitable for gravity type foundations.

For gravity type turbine foundations, where the depth of excavation exceeds the required founding depth for the proposed turbine base, up-fill material consisting of granular fill (6N) shall be used to backfill the excavation to the required founding depth.

For the piled turbine foundations, a typical piling type and configuration could be up to 16 no. 900mm rotary bored piles.

9. FOUNDING DETAILS FOR OTHER INFRASTRUCTURE ELEMENTS

This section provides a summary of the founding details for various elements of the proposed infrastructure across the proposed development site. The detailed methodologies for the construction these elements of the proposed development are included in Chapter 4 of the EIAR.

9.1 Access Roads

Floating access roads are the predominant road construction type proposed for the site which given the ground conditions and type of terrain present is deemed an appropriate construction approach. Where shallow peat is present (<1m), excavate and replace (founded) type construction.

The typical make-up of the floated access roads is a minimum stone thickness of 1000mm with at least one layer of reinforcing geogrid. The necessary stone thickness will be confirmed at detailed design stage.

The typical make-up of the founded access roads is a minimum stone thickness of 500mm. The requirement for a layer of geotextile and geogrid and the necessary stone thickness will be confirmed at detailed design stage.

9.2 Crane Hardstands

The crane hardstands will be constructed using the founded technique (i.e. not floated technique).

Crane hardstands are constructed using compacted Class 1/6F material on a suitable sub-formation to achieve the required bearing resistance. The hardstands will be designed for the most critical loading combinations from the crane.

The hardstands will require to be founded on competent material underlying the peat deposits. The founding levels for the hardstands will be variable across the site and will be determined during detailed ground investigation/design stage.

The typical make-up of the hardstands will include a minimum of 1000mm of granular stone fill with possibly a layer of geotextile and/or geogrid.

9.3 110kv Tail Fed Substation, ESB Compound and Electrical Control Room Foundations & Platforms

The 110kv Tail Fed Substation, ESB Compound and Electrical Control Room platforms will be constructed using the founded technique (i.e. not floated technique). The 110kv Tail Fed Substation, ESB Compound and Electrical Control Room foundations may comprise strip/raft foundations under the main footprint of the building with a basement/pit for cable connections.

These platforms are constructed using compacted Class 1/6F material, in accordance with Eirgrid/ESB network requirements, on a suitable sub-formation to achieve the required bearing resistance.

The 110kv Tail Fed Substation, ESB Compound and Electrical Control Room platforms will be founded on competent material underlying the peat deposits.

Given the ground conditions present at the proposed 110kv Tail Fed Substation, ESB Compound and Electrical Control Room, it is envisaged that the foundations will require to be founded on glacial till. The peat and lacustrine soils will not be a suitable founding stratum for the 110kv Tail Fed Substation, ESB Compound and Electrical Control Room foundations.

The founding depth for the 110kv Tail Fed Substation, ESB Compound and Electrical Control Room platforms will be 0.5-1.0m.

The make-up of the 110kv Tail Fed Substation, ESB Compound and Electrical Control Room platforms will include up to 1000mm of granular stone fill with possibly a layer of geotextile and/or geogrid. At the underside of the foundations, a layer of structural up-fill (class 6N/6P) in accordance with Eirgrid requirements will likely be required.

9.4 Construction Compound Platforms

The construction compound platforms will be constructed using the founded technique (i.e. not floated technique).

The construction compound platforms are generally constructed using compacted Class 1/6F material on a suitable sub-formation to achieve the required bearing resistance.

The construction compound platforms will require to be founded on material underlying the peat deposits.

Typical founding depth for construction compound platform will be 0.5m to 1.0m bgl.

The make-up of the construction compound platform will include up to 1000mm of granular stone fill with possibly a layer of geotextile and/or geogrid.

9.5 Met Mast Foundations

The met mast foundation will likely comprise gravity type foundation.

Given the ground conditions present at the proposed met mast, it is envisaged that the foundation will require to be founded on a competent stratum below the peat.

Typical founding depth for the met mast foundation is envisaged to be 0.5 to 1.5m bgl. At the underside of the met mast foundation, a layer of structural up-fill (class 6N) will be required.

10. SUMMARY AND RECOMMENDATIONS

10.1 Summary

The following summary is given.

FT was engaged by Cush Wind Limited to undertake a geotechnical and peat stability assessment of the proposed Cush wind farm site.

The findings of the peat assessment showed that the site has an acceptable margin of safety and is suitable for the proposed wind farm development. The findings include recommendations and control measures for construction work in peat lands to ensure that all works adhere to an acceptable standard of safety.

The site is relatively flat lying with drainage channels running typically northeast to southwest. The land uses and types within the proposed development site are a mixture of agricultural fields, mature forestry, bare cutover and cutaway peat.

Peat depth recorded during the site walkover and from the ground investigation ranged from 0.1 to 5.0m with an average peat depth of 2.1m. Approximately 90 percent of peat depth probes recorded peat depths of less than 4.0m. A number of localised readings were recorded where peat depths were 4.0 to 5.0m.

Hydro-Environmental Services (HES) carried out trial pitting and soil augers at each turbine location.

Slope inclinations at the main infrastructure locations range from 2 to 6 degrees.

An analysis of peat sliding was carried out at the main infrastructure locations across site for both the undrained and drained conditions. The purpose of the analysis was to determine the Factor of Safety (FoS) of the peat slopes.

For the undrained condition, the calculated FoS for load conditions (1) and (2) for the locations analysed, showed that all locations have an acceptable FoS of greater than 1.3, indicating a low risk of peat failure. The undrained analysis would be considered the most critical condition for the peat slopes.

A drained analysis was also carried out, which examined the effect of in particular, rainfall on the existing stability of the natural peat slopes on site. For the drained condition, the calculated FoS for load conditions (1) & (2) for the locations analysed, showed that all locations have an acceptable FoS of greater than 1.3.

The peat stability risk assessment at each infrastructure location identified a number of mitigation/control measures to reduce the potential risk of peat failure. Sections of access roads to the nearest infrastructure element should be subject to the same mitigation/control measures that apply to the nearest infrastructure element. See Appendix B for details of the required mitigation/control measures for each infrastructure element.

In summary, the findings of the peat assessment showed that the proposed Cush wind farm site has an acceptable margin of safety, is suitable for the proposed wind farm development and is considered to be at low risk of peat failure. The findings include recommendations and control measures for construction work in peat lands to ensure that all works adhere to an acceptable standard of safety.

10.2 Recommendations

The following recommendations are given.

Notwithstanding that the site has an acceptable margin of safety a number of mitigation/control measures are given to ensure that all works adhere to an acceptable standard of safety for work in peatlands. Mitigation/control measures identified for each of the infrastructure elements in the risk assessment will be taken into account and implemented throughout design and construction works (Appendix B).

Figure 4-2 shows areas which have an elevated or higher construction risk due to the terrain and features encountered during the site reconnaissance i.e. presence of relatively deep peat. Figure 6-1 shows the results of the factor of safety (FoS) analysis for the peat slopes on site for the most critical load condition.

To minimise the risk of construction activity causing potential peat instability the Construction Method Statements (CMSs) for the project will take into account, but not be limited, to the recommendations above. This will ensure that best practice guidance regarding the management of peat stability will be inherent in the construction phase.

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APPENDIX A

Photos from Site Walkover

Photo 1: Partially revegetated open peatland (T3)

Photo 2: Agricultural field with no peat (T8)

Photo 3: Mature forestry with shallow peat (T5)

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APPENDIX B

Peat Stability Risk Registers

Cush Wind Farm - Peat Stability Risk Register (Rev 0)

Location:	Turbine T1

Grid Reference (Eastings, Northings):	606797	710446
Distance to Watercourse (m)	50 - 100	
Min & Max Measured Peat Depth (m):	1.5 - 3.3	
Specific Control Required:	No	

		Pre-Control Measure Implementation						Post-Control Measure Implementation			
Ref.	Contributory/Qualitative Factors to Potential Peat Failure	Prob (Note 2)	Impact (Note 3)	Risk	Risk Rating	Control Required	Control measures to be implemented during construction	Prob (Note 2)	Impact (Note 3)	Risk	Risk Rating
1	FOS = 6.85 (u), 4.88 (d)	1	3	3	Negligible	No	See Below	1	3	3	Negligible
2	Evidence of sub peat water flow	1	3	3	Negligible	No		1	3	3	Negligible
3	Evidence of surface water flow	3	3	9	Low	No		3	3	9	Low
4	Evidence of previous failures/slips	0	3	0	Not Applicable	No		0	3	0	Not Applicable
5	Type of vegetation	2	3	6	Low	No		2	3	6	Low
6	General slope characteristics upslope/downslope from infrastructure location	3	3	9	Low	No		3	3	9	Low
7	Evidence of very soft/soft clay at base of peat	0	3	0	Not Applicable	No		0	3	0	Not Applicable
8	Evidence of mechanically cut peat	0	3	0	Not Applicable	No		0	3	0	Not Applicable
9	Evidence of quaking or buoyant peat	0	3	0	Not Applicable	No		0	3	0	Not Applicable
10	Evidence of bog pools	0	3	0	Not Applicable	No		0	3	0	Not Applicable
11	Other	0	3	0	Not Applicable	No		0	3	0	Not Applicable

	General Control Measures to be Implemented Prior to/and During Construction for **Turbine T1**
i	Due to relatively deep peat at this turbine location, additional construction measures such as the following may be required: - excavation side walls to be supported (e.g. boulders, sheet piles) or excavation facew battered to a shallow angle - temporary works designer may be required to provide excavation support design -daily detailed inspection of excavation faces -potential for greater water inflow into excavation requiring removal of water using pumping -increased exclusion zone around excavation to avoid accidental loading of crest of slope
ii	Maintain hydrology of area as far as possible;
iii	Use of experienced geotechnical staff for site investigation;
iv	Use of experienced contractors and trained operators to carry out the work;
v	Detailed ground investigation to determine peat, mineral soil and bedrock condition and properties.
vi	Inspection & approval of turbine base sub-formation by a competent person where a gravity type foundation base is constructed.
vii	Based on available ground investigation, a piled turbine foundation may be required.

Note

(1) FOS abbreviations are: u: FOS for undrained analysis, d: FOS for drained analysis.
(2) Probability assessed as per Table A and B of Appendix D.
(3) Impact based on distance of infrastructure element to nearest watercourse.

Cush Wind Farm - Peat Stability Risk Register (Rev 0)

Location:	Turbine T2

Grid Reference (Eastings, Northings):	606312.39	709829.25
Distance to Watercourse (m)	100 - 150	
Min & Max Measured Peat Depth (m):	0.5 - 4	
Specific Control Required:	No	

		Pre-Control Measure Implementation						Post-Control Measure Implementation			
Ref.	Contributory/Qualitative Factors to Potential Peat Failure	Prob (Note 2)	Impact (Note 3)	Risk	Risk Rating	Control Required	Control measures to be implemented during construction	Prob (Note 2)	Impact (Note 3)	Risk	Risk Rating
1	FOS = 5.57 (u), 4.37 (d)	1	2	2	Negligible	No	See Below	1	2	2	Negligible
2	Evidence of sub peat water flow	1	2	2	Negligible	No		1	2	2	Negligible
3	Evidence of surface water flow	3	2	6	Low	No		3	2	6	Low
4	Evidence of previous failures/slips	0	2	0	Not Applicable	No		0	2	0	Not Applicable
5	Type of vegetation	2	2	4	Negligible	No		2	2	4	Negligible
6	General slope characteristics upslope/downslope from infrastructure location	3	2	6	Low	No		3	2	6	Low
7	Evidence of very soft/soft clay at base of peat	0	2	0	Not Applicable	No		0	2	0	Not Applicable
8	Evidence of mechanically cut peat	0	2	0	Not Applicable	No		0	2	0	Not Applicable
9	Evidence of quaking or buoyant peat	0	2	0	Not Applicable	No		0	2	0	Not Applicable
10	Evidence of bog pools	0	2	0	Not Applicable	No		0	2	0	Not Applicable
11	Other	0	2	0	Not Applicable	No		0	2	0	Not Applicable

	General Control Measures to be Implemented Prior to/and During Construction for **Turbine T2**
i	Due to relatively deep peat at this turbine location, additional construction measures such as the following may be required: - excavation side walls to be supported (e.g. boulders, sheet piles) or excavation facew battered to a shallow angle - temporary works designer may be required to provide excavation support design -daily detailed inspection of excavation faces -potential for greater water inflow into excavation requiring removal of water using pumping -increased exclusion zone around excavation to avoid accidental loading of crest of slope
ii	Maintain hydrology of area as far as possible;
iii	Use of experienced geotechnical staff for site investigation;
iv	Use of experienced contractors and trained operators to carry out the work;
v	Detailed ground investigation to determine peat, mineral soil and bedrock condition and properties.
vi	Inspection & approval of turbine base sub-formation by a competent person where a gravity type foundation base is constructed.
vii	Based on available ground investigation, a piled turbine foundation may be required.

Note

(1) FOS abbreviations are: u: FOS for undrained analysis, d: FOS for drained analysis.
(2) Probability assessed as per Table A and B of Appendix D.
(3) Impact based on distance of infrastructure element to nearest watercourse.

Cush Wind Farm - Peat Stability Risk Register (Rev 0)

Location:	Turbine T3

Grid Reference (Eastings, Northings):	607351.24	710752.73
Distance to Watercourse (m)	> 150	
Min & Max Measured Peat Depth (m):	2 - 3.8	
Specific Control Required:	No	

		Pre-Control Measure Implementation						Post-Control Measure Implementation			
Ref.	Contributory/Qualitative Factors to Potential Peat Failure	Prob (Note 2)	Impact (Note 3)	Risk	Risk Rating	Control Required	Control measures to be implemented during construction	Prob (Note 2)	Impact (Note 3)	Risk	Risk Rating
1	FOS = 12.40 (u), 13.42 (d)	1	1	1	Negligible	No	See Below	1	1	1	Negligible
2	Evidence of sub peat water flow	1	1	1	Negligible	No		1	1	1	Negligible
3	Evidence of surface water flow	3	1	3	Negligible	No		3	1	3	Negligible
4	Evidence of previous failures/slips	0	1	0	Not Applicable	No		0	1	0	Not Applicable
5	Type of vegetation	2	1	2	Negligible	No		2	1	2	Negligible
6	General slope characteristics upslope/downslope from infrastructure location	3	1	3	Negligible	No		2	1	2	Negligible
7	Evidence of very soft/soft clay at base of peat	0	1	0	Not Applicable	No		0	1	0	Not Applicable
8	Evidence of mechanically cut peat	0	1	0	Not Applicable	No		0	1	0	Not Applicable
9	Evidence of quaking or buoyant peat	0	1	0	Not Applicable	No		0	1	0	Not Applicable
10	Evidence of bog pools	0	1	0	Not Applicable	No		0	1	0	Not Applicable
11	Other	0	1	0	Not Applicable	No		0	1	0	Not Applicable

	General Control Measures to be Implemented Prior to/and During Construction for **Turbine T3**
i	Due to relatively deep peat at this turbine location, additional construction measures such as the following may be required: - excavation side walls to be supported (e.g. boulders, sheet piles) or excavation facew battered to a shallow angle - temporary works designer may be required to provide excavation support design -daily detailed inspection of excavation faces -potential for greater water inflow into excavation requiring removal of water using pumping -increased exclusion zone around excavation to avoid accidental loading of crest of slope
ii	Maintain hydrology of area as far as possible;
iii	Use of experienced geotechnical staff for site investigation;
iv	Use of experienced contractors and trained operators to carry out the work;
v	Detailed ground investigation to determine peat, mineral soil and bedrock condition and properties.
vi	Inspection & approval of turbine base sub-formation by a competent person where a gravity type foundation base is constructed.
vii	Based on available ground investigation, a piled turbine foundation may be required.

Note

(1) FOS abbreviations are: u: FOS for undrained analysis, d: FOS for drained analysis.
(2) Probability assessed as per Table A and B of Appendix D.
(3) Impact based on distance of infrastructure element to nearest watercourse.

Cush Wind Farm - Peat Stability Risk Register (Rev 0)

Location:	Turbine T4

Grid Reference (Eastings, Northings):	607059.91	710032.87
Distance to Watercourse (m)	> 150	
Min & Max Measured Peat Depth (m):	1 - 4.3	
Specific Control Required:	No	

		Pre-Control Measure Implementation						Post-Control Measure Implementation			
Ref.	Contributory/Qualitative Factors to Potential Peat Failure	Prob (Note 2)	Impact (Note 3)	Risk	Risk Rating	Control Required	Control measures to be implemented during construction	Prob (Note 2)	Impact (Note 3)	Risk	Risk Rating
1	FOS = 4.03 (u), 2.73 (d)	1	1	1	Negligible	No	See Below	1	1	1	Negligible
2	Evidence of sub peat water flow	1	1	1	Negligible	No		1	1	1	Negligible
3	Evidence of surface water flow	3	1	3	Negligible	No		2	1	2	Negligible
4	Evidence of previous failures/slips	0	1	0	Not Applicable	No		0	1	0	Not Applicable
5	Type of vegetation	2	1	2	Negligible	No		2	1	2	Negligible
6	General slope characteristics upslope/downslope from infrastructure location	3	1	3	Negligible	No		3	1	3	Negligible
7	Evidence of very soft/soft clay at base of peat	0	1	0	Not Applicable	No		0	1	0	Not Applicable
8	Evidence of mechanically cut peat	0	1	0	Not Applicable	No		0	1	0	Not Applicable
9	Evidence of quaking or buoyant peat	0	1	0	Not Applicable	No		0	1	0	Not Applicable
10	Evidence of bog pools	0	1	0	Not Applicable	No		0	1	0	Not Applicable
11	Relatively deep peat	3	1	3	Negligible	No		2	1	2	Negligible

	General Control Measures to be Implemented Prior to/and During Construction for **Turbine T4**
i	Due to relatively deep peat at this turbine location, additional construction measures such as the following may be required: - excavation side walls to be supported (e.g. boulders, sheet piles) or excavation facew battered to a shallow angle - temporary works designer may be required to provide excavation support design -daily detailed inspection of excavation faces -potential for greater water inflow into excavation requiring removal of water using pumping -increased exclusion zone around excavation to avoid accidental loading of crest of slope
ii	Maintain hydrology of area as far as possible;
iii	Use of experienced geotechnical staff for site investigation;
iv	Use of experienced contractors and trained operators to carry out the work;
v	Detailed ground investigation to determine peat, mineral soil and bedrock condition and properties.
vi	Inspection & approval of turbine base sub-formation by a competent person where a gravity type foundation base is constructed.
vii	Based on available ground investigation, a piled turbine foundation may be required.

Note

(1) FOS abbreviations are: u: FOS for undrained analysis, d: FOS for drained analysis.
(2) Probability assessed as per Table A and B of Appendix D.
(3) Impact based on distance of infrastructure element to nearest watercourse.

Cush Wind Farm - Peat Stability Risk Register (Rev 0)

Location:	Turbine T5

Grid Reference (Eastings, Northings):	607922.17	710465.36
Distance to Watercourse (m)	100 - 150	
Min & Max Measured Peat Depth (m):	1.4 - 2.1	
Specific Control Required:	No	

		Pre-Control Measure Implementation						Post-Control Measure Implementation			
Ref.	Contributory/Qualitative Factors to Potential Peat Failure	Prob (Note 2)	Impact (Note 3)	Risk	Risk Rating	Control Required	Control measures to be implemented during construction	Prob (Note 2)	Impact (Note 3)	Risk	Risk Rating
1	FOS = 3.89 (u), 2.34 (d)	1	2	2	Negligible	No	See Below	1	2	2	Negligible
2	Evidence of sub peat water flow	1	2	2	Negligible	No		1	2	2	Negligible
3	Evidence of surface water flow	3	2	6	Low	No		2	2	4	Negligible
4	Evidence of previous failures/slips	0	2	0	Not Applicable	No		0	2	0	Not Applicable
5	Type of vegetation	2	2	4	Negligible	No		2	2	4	Negligible
6	General slope characteristics upslope/downslope from infrastructure location	3	2	6	Low	No		2	2	4	Negligible
7	Evidence of very soft/soft clay at base of peat	0	2	0	Not Applicable	No		0	2	0	Not Applicable
8	Evidence of mechanically cut peat	0	2	0	Not Applicable	No		0	2	0	Not Applicable
9	Evidence of quaking or buoyant peat	0	2	0	Not Applicable	No		0	2	0	Not Applicable
10	Evidence of bog pools	0	2	0	Not Applicable	No		0	2	0	Not Applicable
11	Relatively deep peat	3	2	6	Low	No		2	2	4	Negligible

	General Control Measures to be Implemented Prior to/and During Construction for **Turbine T5**
i	Maintain hydrology of area as far as possible;
ii	Use of experienced geotechnical staff for site investigation;
iii	Use of experienced contractors and trained operators to carry out the work;
iv	Detailed ground investigation to determine peat, mineral soil and bedrock condition and properties.
v	Inspection & approval of turbine base sub-formation by a competent person where a gravity type foundation base is constructed.

Note

(1) FOS abbreviations are: u: FOS for undrained analysis, d: FOS for drained analysis.
(2) Probability assessed as per Table A and B of Appendix D.
(3) Impact based on distance of infrastructure element to nearest watercourse.

Cush Wind Farm - Peat Stability Risk Register (Rev 0)

Location:	Turbine T6	
Grid Reference (Eastings, Northings):	607844	709967
Distance to Watercourse (m)	> 150	
Min & Max Measured Peat Depth (m):	2 - 2.5	
Specific Control Required:	No	

		Pre-Control Measure Implementation						Post-Control Measure Implementation			
Ref.	Contributory/Qualitative Factors to Potential Peat Failure	Prob (Note 2)	Impact (Note 3)	Risk	Risk Rating	Control Required	Control measures to be implemented during construction	Prob (Note 2)	Impact (Note 3)	Risk	Risk Rating
1	FOS = 4.94 (u), 3.64 (d)	1	1	1	Negligible	No	See Below	1	1	1	Negligible
2	Evidence of sub peat water flow	1	1	1	Negligible	No		1	1	1	Negligible
3	Evidence of surface water flow	3	1	3	Negligible	No		3	1	3	Negligible
4	Evidence of previous failures/slips	0	1	0	Not Applicable	No		0	1	0	Not Applicable
5	Type of vegetation	2	1	2	Negligible	No		2	1	2	Negligible
6	General slope characteristics upslope/downslope from infrastructure location	3	1	3	Negligible	No		2	1	2	Negligible
7	Evidence of very soft/soft clay at base of peat	0	1	0	Not Applicable	No		0	1	0	Not Applicable
8	Evidence of mechanically cut peat	0	1	0	Not Applicable	No		0	1	0	Not Applicable
9	Evidence of quaking or buoyant peat	1	1	1	Negligible	No		0	1	0	Not Applicable
10	Evidence of bog pools	0	1	0	Not Applicable	No		0	1	0	Not Applicable
11	Other	0	1	0	Not Applicable	No		0	1	0	Not Applicable

	General Control Measures to be Implemented Prior to/and During Construction for **Turbine T6**
i	Maintain hydrology of area as far as possible;
ii	Use of experienced geotechnical staff for site investigation;
iii	Use of experienced contractors and trained operators to carry out the work;
iv	Detailed ground investigation to determine peat, mineral soil and bedrock condition and properties.
v	Inspection & approval of turbine base sub-formation by a competent person where a gravity type foundation base is constructed.
vi	Based on available ground investigation, a piled turbine foundation may be required.

Note

(1) FOS abbreviations are: u: FOS for undrained analysis, d: FOS for drained analysis.
(2) Probability assessed as per Table A and B of Appendix D.
(3) Impact based on distance of infrastructure element to nearest watercourse.

Cush Wind Farm - Peat Stability Risk Register (Rev 0)

Location:	Turbine T7

Grid Reference (Eastings, Northings):	608285.7	709734.74
Distance to Watercourse (m)	100 - 150	
Min & Max Measured Peat Depth (m):	0.1	
Specific Control Required:	No	

		Pre-Control Measure Implementation						Post-Control Measure Implementation			
Ref.	Contributory/Qualitative Factors to Potential Peat Failure	Prob (Note 2)	Impact (Note 3)	Risk	Risk Rating	Control Required	Control measures to be implemented during construction	Prob (Note 2)	Impact (Note 3)	Risk	Risk Rating
1	FOS = 2.13 (u), 1.31 (d)	1	2	2	Negligible	No	See Below	1	2	2	Negligible
2	Evidence of sub peat water flow	1	2	2	Negligible	No		1	2	2	Negligible
3	Evidence of surface water flow	3	2	6	Low	No		2	2	4	Negligible
4	Evidence of previous failures/slips	0	2	0	Not Applicable	No		0	2	0	Not Applicable
5	Type of vegetation	1	2	2	Negligible	No		2	2	4	Negligible
6	General slope characteristics upslope/downslope from infrastructure location	2	2	4	Negligible	No		2	2	4	Negligible
7	Evidence of very soft/soft clay at base of peat	0	2	0	Not Applicable	No		0	2	0	Not Applicable
8	Evidence of mechanically cut peat	0	2	0	Not Applicable	No		0	2	0	Not Applicable
9	Evidence of quaking or buoyant peat	0	2	0	Not Applicable	No		0	2	0	Not Applicable
10	Evidence of bog pools	0	2	0	Not Applicable	No		0	2	0	Not Applicable
11	Relatively deep peat	3	2	6	Low	No		2	2	4	Negligible

	General Control Measures to be Implemented Prior to/and During Construction for **Turbine T7**
i	Maintain hydrology of area as far as possible;
ii	Use of experienced geotechnical staff for site investigation;
iii	Use of experienced contractors and trained operators to carry out the work;
iv	Detailed ground investigation to determine peat, mineral soil and bedrock condition and properties.
v	Inspection & approval of turbine base sub-formation by a competent person where a gravity type foundation base is constructed.

Note

(1) FOS abbreviations are: u: FOS for undrained analysis, d: FOS for drained analysis.
(2) Probability assessed as per Table A and B of Appendix D.
(3) Impact based on distance of infrastructure element to nearest watercourse.

Cush Wind Farm - Peat Stability Risk Register (Rev 0)

Location:	Turbine T8

Grid Reference (Eastings, Northings):	608427.05	710194.84
Distance to Watercourse (m)	> 150	
Min & Max Measured Peat Depth (m):	0.1 - 0.4	
Specific Control Required:	No	

		Pre-Control Measure Implementation						Post-Control Measure Implementation			
Ref.	Contributory/Qualitative Factors to Potential Peat Failure	Prob (Note 2)	Impact (Note 3)	Risk	Risk Rating	Control Required	Control measures to be implemented during construction	Prob (Note 2)	Impact (Note 3)	Risk	Risk Rating
1	FOS = 4.78 (u), 3.02 (d)	1	1	1	Negligible	No	See Below	1	1	1	Negligible
2	Evidence of sub peat water flow	1	1	1	Negligible	No		1	1	1	Negligible
3	Evidence of surface water flow	3	1	3	Negligible	No		2	1	2	Negligible
4	Evidence of previous failures/slips	0	1	0	Not Applicable	No		0	1	0	Not Applicable
5	Type of vegetation	2	1	2	Negligible	No		2	1	2	Negligible
6	General slope characteristics upslope/downslope from infrastructure location	3	1	3	Negligible	No		2	1	2	Negligible
7	Evidence of very soft/soft clay at base of peat	0	1	0	Not Applicable	No		0	1	0	Not Applicable
8	Evidence of mechanically cut peat	0	1	0	Not Applicable	No		0	1	0	Not Applicable
9	Evidence of quaking or buoyant peat	0	1	0	Not Applicable	No		0	1	0	Not Applicable
10	Evidence of bog pools	0	1	0	Not Applicable	No		0	1	0	Not Applicable
11	Relatively deep peat	3	1	3	Negligible	No		2	1	2	Negligible

	General Control Measures to be Implemented Prior to/and During Construction for **Turbine T8**
i	Maintain hydrology of area as far as possible;
ii	Use of experienced geotechnical staff for site investigation;
iii	Use of experienced contractors and trained operators to carry out the work;
iv	Detailed ground investigation to determine peat, mineral soil and bedrock condition and properties.
v	Inspection & approval of turbine base sub-formation by a competent person where a gravity type foundation base is constructed.

Note

(1) FOS abbreviations are: u: FOS for undrained analysis, d: FOS for drained analysis.
(2) Probability assessed as per Table A and B of Appendix D.
(3) Impact based on distance of infrastructure element to nearest watercourse.

Cush Wind Farm - Peat Stability Risk Register (Rev 0)

Location:	Met. Mast

Grid Reference (Eastings, Northings):	608482.76	709505.88
Distance to Watercourse (m)	> 150	
Min & Max Measured Peat Depth (m):	0.5	
Specific Control Required:	No	

		Pre-Control Measure Implementation						Post-Control Measure Implementation			
Ref.	Contributory/Qualitative Factors to Potential Peat Failure	Prob (Note 2)	Impact (Note 3)	Risk	Risk Rating	Control Required	Control measures to be implemented during construction	Prob (Note 2)	Impact (Note 3)	Risk	Risk Rating
1	FOS = 5.73 (u), 3.82 (d)	1	1	1	Negligible	No	See Below	1	1	1	Negligible
2	Evidence of sub peat water flow	1	1	1	Negligible	No		1	1	1	Negligible
3	Evidence of surface water flow	3	1	3	Negligible	No		3	1	3	Negligible
4	Evidence of previous failures/slips	0	1	0	Not Applicable	No		0	1	0	Not Applicable
5	Type of vegetation	2	1	2	Negligible	No		2	1	2	Negligible
6	General slope characteristics upslope/downslope from infrastructure location	3	1	3	Negligible	No		3	1	3	Negligible
7	Evidence of very soft/soft clay at base of peat	0	1	0	Not Applicable	No		0	1	0	Not Applicable
8	Evidence of mechanically cut peat	0	1	0	Not Applicable	No		0	1	0	Not Applicable
9	Evidence of quaking or buoyant peat	0	1	0	Not Applicable	No		0	1	0	Not Applicable
10	Evidence of bog pools	0	1	0	Not Applicable	No		0	1	0	Not Applicable
11	Relatively deep peat	3	1	3	Negligible	No		2	1	2	Negligible

	General Control Measures to be Implemented Prior to/and During Construction for **Met. Mast**
ii	Maintain hydrology of area as far as possible;
ii	Use of experienced geotechnical staff for site investigation;
iii	Use of experienced contractors and trained operators to carry out the work;
iv	Detailed ground investigation to determine peat, mineral soil and bedrock condition and properties.
v	Inspection & approval of turbine base sub-formation by a competent person where a gravity type foundation base is constructed.

Note

(1) FOS abbreviations are: u: FOS for undrained analysis, d: FOS for drained analysis.
(2) Probability assessed as per Table A and B of Appendix D.
(3) Impact based on distance of infrastructure element to nearest watercourse.

Cush Wind Farm - Peat Stability Risk Register (Rev 0)

Location:	Construction Compound 1

Grid Reference (Eastings, Northings):	608482.76	709505.88
Distance to Watercourse (m)	> 150	
Min & Max Measured Peat Depth (m):	0.3 - 1.5	
Specific Control Required:	No	

		Pre-Control Measure Implementation						Post-Control Measure Implementation			
Ref.	Contributory/Qualitative Factors to Potential Peat Failure	Prob (Note 2)	Impact (Note 3)	Risk	Risk Rating	Control Required	Control measures to be implemented during construction	Prob (Note 2)	Impact (Note 3)	Risk	Risk Rating
1	FOS = 5.73 (u), 3.82 (d)	1	1	1	Negligible	No	See Below	1	1	1	Negligible
2	Evidence of sub peat water flow	1	1	1	Negligible	No		1	1	1	Negligible
3	Evidence of surface water flow	3	1	3	Negligible	No		3	1	3	Negligible
4	Evidence of previous failures/slips	0	1	0	Not Applicable	No		0	1	0	Not Applicable
5	Type of vegetation	2	1	2	Negligible	No		2	1	2	Negligible
6	General slope characteristics upslope/downslope from infrastructure location	3	1	3	Negligible	No		3	1	3	Negligible
7	Evidence of very soft/soft clay at base of peat	0	1	0	Not Applicable	No		0	1	0	Not Applicable
8	Evidence of mechanically cut peat	0	1	0	Not Applicable	No		0	1	0	Not Applicable
9	Evidence of quaking or buoyant peat	0	1	0	Not Applicable	No		0	1	0	Not Applicable
10	Evidence of bog pools	0	1	0	Not Applicable	No		0	1	0	Not Applicable
11	Relatively deep peat	3	1	3	Negligible	No		2	1	2	Negligible

	General Control Measures to be Implemented Prior to/and During Construction for **Construction Compound 1**
ii	Maintain hydrology of area as far as possible;
ii	Use of experienced geotechnical staff for site investigation;
iii	Use of experienced contractors and trained operators to carry out the work;
iv	Detailed ground investigation to determine peat, mineral soil and bedrock condition and properties.
v	Inspection & approval of turbine base sub-formation by a competent person where a gravity type foundation base is constructed.

Note

(1) FOS abbreviations are: u: FOS for undrained analysis, d: FOS for drained analysis.
(2) Probability assessed as per Table A and B of Appendix D.
(3) Impact based on distance of infrastructure element to nearest watercourse.

Cush Wind Farm - Peat Stability Risk Register (Rev 0)

Location:	Construction Compound 2

Grid Reference (Eastings, Northings):	608374	710304
Distance to Watercourse (m)	> 150	
Min & Max Measured Peat Depth (m):	0.2	
Specific Control Required:	No	

		Pre-Control Measure Implementation						Post-Control Measure Implementation			
Ref.	Contributory/Qualitative Factors to Potential Peat Failure	Prob (Note 2)	Impact (Note 3)	Risk	Risk Rating	Control Required	Control measures to be implemented during construction	Prob (Note 2)	Impact (Note 3)	Risk	Risk Rating
1	FOS = 5.73 (u), 3.82 (d)	1	1	1	Negligible	No	See Below	1	1	1	Negligible
2	Evidence of sub peat water flow	1	1	1	Negligible	No		1	1	1	Negligible
3	Evidence of surface water flow	3	1	3	Negligible	No		3	1	3	Negligible
4	Evidence of previous failures/slips	0	1	0	Not Applicable	No		0	1	0	Not Applicable
5	Type of vegetation	2	1	2	Negligible	No		2	1	2	Negligible
6	General slope characteristics upslope/downslope from infrastructure location	3	1	3	Negligible	No		3	1	3	Negligible
7	Evidence of very soft/soft clay at base of peat	0	1	0	Not Applicable	No		0	1	0	Not Applicable
8	Evidence of mechanically cut peat	0	1	0	Not Applicable	No		0	1	0	Not Applicable
9	Evidence of quaking or buoyant peat	0	1	0	Not Applicable	No		0	1	0	Not Applicable
10	Evidence of bog pools	0	1	0	Not Applicable	No		0	1	0	Not Applicable
11	Relatively deep peat	3	1	3	Negligible	No		2	1	2	Negligible

	General Control Measures to be Implemented Prior to/and During Construction for **Construction Compound 2**
ii	Maintain hydrology of area as far as possible;
ii	Use of experienced geotechnical staff for site investigation;
iii	Use of experienced contractors and trained operators to carry out the work;
iv	Detailed ground investigation to determine peat, mineral soil and bedrock condition and properties.
v	Inspection & approval of turbine base sub-formation by a competent person where a gravity type foundation base is constructed.

Note

(1) FOS abbreviations are: u: FOS for undrained analysis, d: FOS for drained analysis.
(2) Probability assessed as per Table A and B of Appendix D.
(3) Impact based on distance of infrastructure element to nearest watercourse.

Cush Wind Farm - Peat Stability Risk Register (Rev 0)

Location:	Site Entrance to T2

Grid Reference (Eastings, Northings):	Varies
Distance to Watercourse (m)	
Min & Max Measured Peat Depth (m):	
Specific Control Required:	No

		Pre-Control Measure Implementation						Post-Control Measure Implementation			
Ref.	Contributory/Qualitative Factors to Potential Peat Failure	Prob (Note 2)	Impact (Note 3)	Risk	Risk Rating	Control Required	Control measures to be implemented during construction	Prob (Note 2)	Impact (Note 3)	Risk	Risk Rating
1	FOS = 6.55 (u), 4.59 (d)	1	FALSE	0	Not Applicable	No	See Below	1	FALSE	0	Not Applicable
2	Evidence of sub peat water flow	1	FALSE	0	Not Applicable	No		1	FALSE	0	Not Applicable
3	Evidence of surface water flow	3	FALSE	0	Not Applicable	No		2	FALSE	0	Not Applicable
4	Evidence of previous failures/slips	0	FALSE	0	Not Applicable	No		0	FALSE	0	Not Applicable
5	Type of vegetation	2	FALSE	0	Not Applicable	No		2	FALSE	0	Not Applicable
6	General slope characteristics upslope/downslope from infrastructure location	2	FALSE	0	Not Applicable	No		2	FALSE	0	Not Applicable
7	Evidence of very soft/soft clay at base of peat	0	FALSE	0	Not Applicable	No		0	FALSE	0	Not Applicable
8	Evidence of mechanically cut peat	0	FALSE	0	Not Applicable	No		0	FALSE	0	Not Applicable
9	Evidence of quaking or buoyant peat	3	FALSE	0	Not Applicable	No		2	FALSE	0	Not Applicable
10	Evidence of bog pools	0	FALSE	0	Not Applicable	No		0	FALSE	0	Not Applicable
11	Other	0	FALSE	0	Not Applicable	No		0	FALSE	0	Not Applicable

	General Control Measures to be Implemented Prior to/and During Construction for **Main Entrance Road to T2**
i	Maintain hydrology of area as far as possible;
ii	Installation of appropriate drainge measures to alleviate ingress of surface water into excavations
iii	Use of experienced geotechnical staff for site investigation;
iv	Use of experienced contractors and trained operators to carry out the work;
v	Detailed ground investigation to determine peat, mineral soil and bedrock condition and properties.

Note

(1) FOS abbreviations are: u: FOS for undrained analysis, d: FOS for drained analysis.
(2) Probability assessed as per Table A and B of Appendix D.
(3) Impact based on distance of infrastructure element to nearest watercourse.

Cush Wind Farm - Peat Stability Risk Register (Rev 0)

Location:	T2 to T4

Grid Reference (Eastings, Northings):	Varies
Distance to Watercourse (m)	
Min & Max Measured Peat Depth (m):	
Specific Control Required:	No

		Pre-Control Measure Implementation						Post-Control Measure Implementation			
Ref.	Contributory/Qualitative Factors to Potential Peat Failure	Prob (Note 2)	Impact (Note 3)	Risk	Risk Rating	Control Required	Control measures to be implemented during construction	Prob (Note 2)	Impact (Note 3)	Risk	Risk Rating
1	FOS = 4.39 (u), 4.19 (d)	1	FALSE	0	Not Applicable	No	See Below	1	FALSE	0	Not Applicable
2	Evidence of sub peat water flow	1	FALSE	0	Not Applicable	No		1	FALSE	0	Not Applicable
3	Evidence of surface water flow	2	FALSE	0	Not Applicable	No		1	FALSE	0	Not Applicable
4	Evidence of previous failures/slips	0	FALSE	0	Not Applicable	No		0	FALSE	0	Not Applicable
5	Type of vegetation	2	FALSE	0	Not Applicable	No		1	FALSE	0	Not Applicable
6	General slope characteristics upslope/downslope from infrastructure location	2	FALSE	0	Not Applicable	No		1	FALSE	0	Not Applicable
7	Evidence of very soft/soft clay at base of peat	0	FALSE	0	Not Applicable	No		0	FALSE	0	Not Applicable
8	Evidence of mechanically cut peat	0	FALSE	0	Not Applicable	No		0	FALSE	0	Not Applicable
9	Evidence of quaking or buoyant peat	0	FALSE	0	Not Applicable	No		0	FALSE	0	Not Applicable
10	Evidence of bog pools	0	FALSE	0	Not Applicable	No		0	FALSE	0	Not Applicable
11	Other	0	FALSE	0	Not Applicable	No		0	FALSE	0	Not Applicable

	General Control Measures to be Implemented Prior to/and During Construction for **T2 to T4**
i	Maintain hydrology of area as far as possible;
ii	Use of experienced geotechnical staff for site investigation;
iii	Use of experienced contractors and trained operators to carry out the work;
iv	Detailed ground investigation to determine peat, mineral soil and bedrock condition and properties.

Note

(1) FOS abbreviations are: u: FOS for undrained analysis, d: FOS for drained analysis.
(2) Probability assessed as per Table A and B of Appendix D.
(3) Impact based on distance of infrastructure element to nearest watercourse.

Cush Wind Farm - Peat Stability Risk Register (Rev 0)

Location:	T1 to T3

Grid Reference (Eastings, Northings):	Varies
Distance to Watercourse (m)	
Min & Max Measured Peat Depth (m):	
Specific Control Required:	No

		Pre-Control Measure Implementation						Post-Control Measure Implementation			
Ref.	Contributory/Qualitative Factors to Potential Peat Failure	Prob (Note 2)	Impact (Note 3)	Risk	Risk Rating	Control Required	Control measures to be implemented during construction	Prob (Note 2)	Impact (Note 3)	Risk	Risk Rating
1	FOS = 5.78 (u), 6.21 (d)	1	FALSE	0	Not Applicable	No	See Below	1	FALSE	0	Not Applicable
2	Evidence of sub peat water flow	1	FALSE	0	Not Applicable	No		1	FALSE	0	Not Applicable
3	Evidence of surface water flow	2	FALSE	0	Not Applicable	No		1	FALSE	0	Not Applicable
4	Evidence of previous failures/slips	0	FALSE	0	Not Applicable	No		0	FALSE	0	Not Applicable
5	Type of vegetation	2	FALSE	0	Not Applicable	No		1	FALSE	0	Not Applicable
6	General slope characteristics upslope/downslope from infrastructure location	2	FALSE	0	Not Applicable	No		1	FALSE	0	Not Applicable
7	Evidence of very soft/soft clay at base of peat	0	FALSE	0	Not Applicable	No		0	FALSE	0	Not Applicable
8	Evidence of mechanically cut peat	0	FALSE	0	Not Applicable	No		0	FALSE	0	Not Applicable
9	Evidence of quaking or buoyant peat	0	FALSE	0	Not Applicable	No		0	FALSE	0	Not Applicable
10	Evidence of bog pools	0	FALSE	0	Not Applicable	No		0	FALSE	0	Not Applicable
11	Other	0	FALSE	0	Not Applicable	No		0	FALSE	0	Not Applicable

	General Control Measures to be Implemented Prior to/and During Construction for **T1 to T3**
i	Maintain hydrology of area as far as possible;
ii	Use of experienced geotechnical staff for site investigation;
iii	Use of experienced contractors and trained operators to carry out the work;
iv	Detailed ground investigation to determine peat, mineral soil and bedrock condition and properties.

Note

(1) FOS abbreviations are: u: FOS for undrained analysis, d: FOS for drained analysis.
(2) Probability assessed as per Table A and B of Appendix D.
(3) Impact based on distance of infrastructure element to nearest watercourse.

Cush Wind Farm - Peat Stability Risk Register (Rev 0)

Location:	T4 to T6

Grid Reference (Eastings, Northings):	Varies
Distance to Watercourse (m)	
Min & Max Measured Peat Depth (m):	
Specific Control Required:	No

		Pre-Control Measure Implementation						Post-Control Measure Implementation			
Ref.	Contributory/Qualitative Factors to Potential Peat Failure	Prob (Note 2)	Impact (Note 3)	Risk	Risk Rating	Control Required	Control measures to be implemented during construction	Prob (Note 2)	Impact (Note 3)	Risk	Risk Rating
1	FOS = 5.29 (u), 5.47 (d)	1	FALSE	0	Not Applicable	No	See Below	1	FALSE	0	Not Applicable
2	Evidence of sub peat water flow	1	FALSE	0	Not Applicable	No		1	FALSE	0	Not Applicable
3	Evidence of surface water flow	2	FALSE	0	Not Applicable	No		1	FALSE	0	Not Applicable
4	Evidence of previous failures/slips	0	FALSE	0	Not Applicable	No		0	FALSE	0	Not Applicable
5	Type of vegetation	2	FALSE	0	Not Applicable	No		1	FALSE	0	Not Applicable
6	General slope characteristics upslope/downslope from infrastructure location	2	FALSE	0	Not Applicable	No		1	FALSE	0	Not Applicable
7	Evidence of very soft/soft clay at base of peat	0	FALSE	0	Not Applicable	No		0	FALSE	0	Not Applicable
8	Evidence of mechanically cut peat	0	FALSE	0	Not Applicable	No		0	FALSE	0	Not Applicable
9	Evidence of quaking or buoyant peat	0	FALSE	0	Not Applicable	No		0	FALSE	0	Not Applicable
10	Evidence of bog pools	0	FALSE	0	Not Applicable	No		0	FALSE	0	Not Applicable
11	Other	0	FALSE	0	Not Applicable	No		0	FALSE	0	Not Applicable

	General Control Measures to be Implemented Prior to/and During Construction for **T4 to T6**
i	Maintain hydrology of area as far as possible;
ii	Use of experienced geotechnical staff for site investigation;
iii	Use of experienced contractors and trained operators to carry out the work;
iv	Detailed ground investigation to determine peat, mineral soil and bedrock condition and properties.

Note

(1) FOS abbreviations are: u: FOS for undrained analysis, d: FOS for drained analysis.
(2) Probability assessed as per Table A and B of Appendix D.
(3) Impact based on distance of infrastructure element to nearest watercourse.

Cush Wind Farm - Peat Stability Risk Register (Rev 0)

Location:	T5 to T7

Grid Reference (Eastings, Northings):	Varies
Distance to Watercourse (m)	
Min & Max Measured Peat Depth (m):	
Specific Control Required:	No

		Pre-Control Measure Implementation						Post-Control Measure Implementation			
Ref.	Contributory/Qualitative Factors to Potential Peat Failure	Prob (Note 2)	Impact (Note 3)	Risk	Risk Rating	Control Required	Control measures to be implemented during construction	Prob (Note 2)	Impact (Note 3)	Risk	Risk Rating
1	FOS = 3.67 (u), 3.95 (d)	1	FALSE	0	Not Applicable	No	See Below	1	FALSE	0	Not Applicable
2	Evidence of sub peat water flow	1	FALSE	0	Not Applicable	No		1	FALSE	0	Not Applicable
3	Evidence of surface water flow	2	FALSE	0	Not Applicable	No		1	FALSE	0	Not Applicable
4	Evidence of previous failures/slips	0	FALSE	0	Not Applicable	No		0	FALSE	0	Not Applicable
5	Type of vegetation	2	FALSE	0	Not Applicable	No		1	FALSE	0	Not Applicable
6	General slope characteristics upslope/downslope from infrastructure location	2	FALSE	0	Not Applicable	No		1	FALSE	0	Not Applicable
7	Evidence of very soft/soft clay at base of peat	0	FALSE	0	Not Applicable	No		0	FALSE	0	Not Applicable
8	Evidence of mechanically cut peat	0	FALSE	0	Not Applicable	No		0	FALSE	0	Not Applicable
9	Evidence of quaking or buoyant peat	0	FALSE	0	Not Applicable	No		0	FALSE	0	Not Applicable
10	Evidence of bog pools	0	FALSE	0	Not Applicable	No		0	FALSE	0	Not Applicable
11	Other	0	FALSE	0	Not Applicable	No		0	FALSE	0	Not Applicable

	General Control Measures to be Implemented Prior to/and During Construction for **T5 to T7**
i	Maintain hydrology of area as far as possible;
ii	Use of experienced geotechnical staff for site investigation;
iii	Use of experienced contractors and trained operators to carry out the work;
iv	Detailed ground investigation to determine peat, mineral soil and bedrock condition and properties.

Note

(1) FOS abbreviations are: u: FOS for undrained analysis, d: FOS for drained analysis.
(2) Probability assessed as per Table A and B of Appendix D.
(3) Impact based on distance of infrastructure element to nearest watercourse.

Cush Wind Farm - Peat Stability Risk Register (Rev 0)

Location:	T4 to T7

Grid Reference (Eastings, Northings):	Varies
Distance to Watercourse (m)	
Min & Max Measured Peat Depth (m):	
Specific Control Required:	No

		Pre-Control Measure Implementation						Post-Control Measure Implementation			
Ref.	Contributory/Qualitative Factors to Potential Peat Failure	Prob (Note 2)	Impact (Note 3)	Risk	Risk Rating	Control Required	Control measures to be implemented during construction	Prob (Note 2)	Impact (Note 3)	Risk	Risk Rating
1	FOS = 12.76 (u), 13.795 (d)	1	FALSE	0	Not Applicable	No	See Below	1	FALSE	0	Not Applicable
2	Evidence of sub peat water flow	1	FALSE	0	Not Applicable	No		1	FALSE	0	Not Applicable
3	Evidence of surface water flow	2	FALSE	0	Not Applicable	No		1	FALSE	0	Not Applicable
4	Evidence of previous failures/slips	0	FALSE	0	Not Applicable	No		0	FALSE	0	Not Applicable
5	Type of vegetation	2	FALSE	0	Not Applicable	No		1	FALSE	0	Not Applicable
6	General slope characteristics upslope/downslope from infrastructure location	2	FALSE	0	Not Applicable	No		1	FALSE	0	Not Applicable
7	Evidence of very soft/soft clay at base of peat	0	FALSE	0	Not Applicable	No		0	FALSE	0	Not Applicable
8	Evidence of mechanically cut peat	0	FALSE	0	Not Applicable	No		0	FALSE	0	Not Applicable
9	Evidence of quaking or buoyant peat	0	FALSE	0	Not Applicable	No		0	FALSE	0	Not Applicable
10	Evidence of bog pools	0	FALSE	0	Not Applicable	No		0	FALSE	0	Not Applicable
11	Other	0	FALSE	0	Not Applicable	No		0	FALSE	0	Not Applicable

	General Control Measures to be Implemented Prior to/and During Construction for **T4 to T7**
i	Maintain hydrology of area as far as possible;
ii	Use of experienced geotechnical staff for site investigation;
iii	Use of experienced contractors and trained operators to carry out the work;
iv	Detailed ground investigation to determine peat, mineral soil and bedrock condition and properties.

Note

(1) FOS abbreviations are: u: FOS for undrained analysis, d: FOS for drained analysis.
(2) Probability assessed as per Table A and B of Appendix D.
(3) Impact based on distance of infrastructure element to nearest watercourse.

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APPENDIX C

Calculated FOS for Peat Slopes on Site

Calculated FoS of Natural Peat Slopes for Cush Wind Farm - Drained Analysis

Turbine No./Waypoint	Slope	Design c'	Bulk unit weight of Peat	Unit weight of Water	Depth of In situ Peat	Friction Angle	Surcharge Equivalent Placed Fill	Equivalent Total Depth of Peat (m)	Factor of Safety for Load Condition	
	α (deg)	c' (kPa)	γ (kN/m^3)	γ_w (kN/m^3)	(m)	ø' (deg)	Condition (2)	Condition (2)	Condition (1)	Condition (2)
									100% Water	100% Water
1	6	No peat recorded at this location								
2	4	No peat recorded at this location								
3	4	No peat recorded at this location								
4	2	No peat recorded at this location								
5	2	4	10.0	10.0	0.1	25	1.0	1.1	**114.68**	**22.57**
6	2	4	10.0	10.0	0.8	25	1.0	1.8	**14.34**	**13.79**
7	2	4	10.0	10.0	1.8	25	1.0	2.8	**6.37**	**8.86**
8	3	4	10.0	10.0	2	25	1.0	3.0	**3.83**	**5.52**
9	2	4	10.0	10.0	2.7	25	1.0	3.7	**4.25**	**6.71**
10	3	4	10.0	10.0	2.5	25	1.0	3.5	**3.06**	**4.73**
11	4	4	10.0	10.0	3.2	25	1.0	4.2	**1.80**	**2.96**
12	3	4	10.0	10.0	0.9	25	1.0	1.9	**8.50**	**8.71**
13	2	4	10.0	10.0	1	25	1.0	2.0	**11.47**	**12.41**
14	3	4	10.0	10.0	1.5	25	1.0	2.5	**5.10**	**6.62**
15	3	4	10.0	10.0	1.1	25	1.0	2.1	**6.96**	**7.88**
16	3	4	10.0	10.0	0.2	25	1.0	1.2	**38.27**	**13.79**
17	3	4	10.0	10.0	0.5	25	1.0	1.5	**15.31**	**11.03**
18	4	4	10.0	10.0	0.6	25	1.0	1.6	**9.58**	**7.76**
19	3	4	10.0	10.0	1	25	1.0	2.0	**7.65**	**8.28**
20	3	4	10.0	10.0	1.5	25	1.0	2.5	**5.10**	**6.62**
21	2	4	10.0	10.0	2.2	25	1.0	3.2	**5.21**	**7.76**
22	2	4	10.0	10.0	2.4	25	1.0	3.4	**4.78**	**7.30**
23	2	4	10.0	10.0	1.8	25	1.0	2.8	**6.37**	**8.86**
24	2	4	10.0	10.0	3.6	25	1.0	4.6	**3.19**	**5.40**
25	3	4	10.0	10.0	3.8	25	1.0	4.8	**2.01**	**3.45**
26	2	4	10.0	10.0	3.8	25	1.0	4.8	**3.02**	**5.17**
27	2	4	10.0	10.0	4	25	1.0	5.0	**2.87**	**4.96**
28	2	4	10.0	10.0	2.8	25	1.0	3.8	**4.10**	**6.53**
29	4	4	10.0	10.0	2.2	25	1.0	3.2	**2.61**	**3.88**
30	2	4	10.0	10.0	1.1	25	1.0	2.1	**10.43**	**11.82**
31	6	4	10.0	10.0	1.2	25	1.0	2.2	**3.21**	**3.77**
32	8	4	10.0	10.0	0.5	25	1.0	1.5	**5.80**	**4.15**
33	3	4	10.0	10.0	1.7	25	1.0	2.7	**4.50**	**6.13**
34	2	4	10.0	10.0	1.3	25	1.0	2.3	**8.82**	**10.79**
35	2	4	10.0	10.0	3.6	25	1.0	4.6	**3.19**	**5.40**
36	2	4	10.0	10.0	0.3	25	1.0	1.3	**51.58**	**22.18**
37	2	4	10.0	10.0	0.4	25	1.0	1.4	**42.02**	**21.55**
38	3	4	10.0	10.0	2.8	25	1.0	3.8	**11.63**	**10.91**
39	2	4	10.0	10.0	2.7	25	1.0	3.7	**17.60**	**16.45**
40	2	4	10.0	10.0	3	25	1.0	4.0	**17.18**	**16.22**
41	2	4	10.0	10.0	1.8	25	1.0	2.8	**19.72**	**17.45**
42	2	4	10.0	10.0	4	25	1.0	5.0	**16.22**	**15.65**
43	2	4	10.0	10.0	3.6	25	1.0	4.6	**16.54**	**15.85**
44	2	4	10.0	10.0	0.3	25	1.0	1.3	**51.58**	**22.18**
45	2	4	10.0	10.0	1	25	1.0	2.0	**24.82**	**19.09**
46	2	4	10.0	10.0	3.6	25	1.0	4.6	**16.54**	**15.85**
47	2	4	10.0	10.0	3.6	25	1.0	4.6	**16.54**	**15.85**
48	2	4	10.0	10.0	3.8	25	1.0	4.8	**16.37**	**15.74**
49	6	4	10.0	10.0	1	25	1.0	2.0	**8.28**	**6.36**
50	2	4	10.0	10.0	0.4	25	1.0	1.4	**42.02**	**21.55**
51	4	4	10.0	10.0	0.4	25	1.0	1.4	**21.04**	**10.77**
52	2	4	10.0	10.0	1.3	25	1.0	2.3	**22.18**	**18.34**
53	2	4	10.0	10.0	2.2	25	1.0	3.2	**18.57**	**16.94**
54	2	4	10.0	10.0	2.4	25	1.0	3.4	**18.13**	**16.73**
55	6	4	10.0	10.0	0.3	25	1.0	1.3	**17.26**	**7.40**
56	2	4	10.0	10.0	1.2	25	1.0	2.2	**22.91**	**18.57**
57	3	4	10.0	10.0	2	25	1.0	3.0	**12.72**	**11.45**
58	3	4	10.0	10.0	1.9	25	1.0	2.9	**12.93**	**11.54**
59	3	4	10.0	10.0	1.7	25	1.0	2.7	**13.40**	**11.73**
60	2	4	10.0	10.0	1.6	25	1.0	2.6	**20.52**	**17.76**
61	3	4	10.0	10.0	1.7	25	1.0	2.7	**13.40**	**11.73**
62	2	4	10.0	10.0	2	25	1.0	3.0	**19.09**	**17.18**
63	2	4	10.0	10.0	1.5	25	1.0	2.5	**21.00**	**17.94**
64	4	4	10.0	10.0	1.7	25	1.0	2.7	**10.05**	**8.80**
65	4	4	10.0	10.0	1.8	25	1.0	2.8	**9.86**	**8.72**
66	2	4	10.0	10.0	3.6	25	1.0	4.6	**16.54**	**15.85**
67	2	4	10.0	10.0	0.2	25	1.0	1.2	**70.70**	**22.91**
68	4	4	10.0	10.0	0.2	25	1.0	1.2	**35.41**	**11.46**
69	4	4	10.0	10.0	0.1	25	1.0	1.1	**64.15**	**11.89**
70	2	4	10.0	10.0	3.5	25	1.0	4.5	**16.63**	**15.90**
71	3	4	10.0	10.0	3	25	1.0	4.0	**11.45**	**10.81**
72	3	4	10.0	10.0	2.5	25	1.0	3.5	**11.96**	**11.08**
73	3	4	10.0	10.0	2	25	1.0	3.0	**12.72**	**11.45**
74	6	4	10.0	10.0	0.4	25	1.0	1.4	**14.06**	**7.19**
75	6	4	10.0	10.0	0.4	25	1.0	1.4	**14.06**	**7.19**
76	3	4	10.0	10.0	2	25	1.0	3.0	**12.72**	**11.45**
77	4	4	10.0	10.0	1.9	25	1.0	2.9	**9.69**	**8.65**
78	3	No peat recorded at this location								
79	2	No peat recorded at this location								
80	2	No peat recorded at this location								
81	3	4	10.0	10.0	0.1	25	1.0	1.1	**85.43**	**15.86**
82	3	4	10.0	10.0	0.1	25	1.0	1.1	**85.43**	**15.86**
83	3	4	10.0	10.0	0.2	25	1.0	1.2	**47.16**	**15.28**
84	4	4	10.0	10.0	1.9	25	1.0	2.9	**9.69**	**8.65**
85	2	4	10.0	10.0	1.2	25	1.0	2.2	**22.91**	**18.57**
86	3	4	10.0	10.0	1.9	25	1.0	2.9	**12.93**	**11.54**
87	3	4	10.0	10.0	3.9	25	1.0	4.9	**10.86**	**10.46**
88	3	4	10.0	10.0	3.4	25	1.0	4.4	**11.15**	**10.64**
89	3	4	10.0	10.0	3.5	25	1.0	4.5	**11.08**	**10.60**
90	4	4	10.0	10.0	3	25	1.0	4.0	**8.58**	**8.11**
91	3	4	10.0	10.0	4.5	25	1.0	5.5	**10.60**	**10.29**
92	2	4	10.0	10.0	4.3	25	1.0	5.3	**16.02**	**15.52**
93	3	4	10.0	10.0	3.8	25	1.0	4.8	**10.91**	**10.49**
94	4	4	10.0	10.0	4.5	25	1.0	5.5	**7.95**	**7.71**
95	2	4	10.0	10.0	4	25	1.0	5.0	**16.22**	**15.65**

Calculated FoS of Natural Peat Slopes for Cush Wind Farm - Drained Analysis

Turbine No./Waypoint	Slope	Design c'	Bulk unit weight of Peat	Unit weight of Water	Depth of In situ Peat	Friction Angle	Surcharge Equivalent Placed Fill	Equivalent Total Depth of Peat (m)	Factor of Safety for Load Condition	
	α (deg)	c' (kPa)	γ (kN/m^3)	γ_w (kN/m^3)	(m)	ø' (deg)	Condition (2)	Condition (2)	Condition (1)	Condition (2)
									100% Water	100% Water
96	3	4	10.0	10.0	4.3	25	1.0	5.3	**10.68**	**10.34**
97	2	4	10.0	10.0	4.6	25	1.0	5.6	**15.85**	**15.40**
98	3	4	10.0	10.0	5	25	1.0	6.0	**10.43**	**10.17**
99	3	4	10.0	10.0	4.4	25	1.0	5.4	**10.64**	**10.31**
100	3	4	10.0	10.0	5	25	1.0	6.0	**10.43**	**10.17**
101	4	No peat recorded at this location								
102	6	No peat recorded at this location								
103	8	No peat recorded at this location								
104	10	No peat recorded at this location								
105	8	No peat recorded at this location								
106	8	No peat recorded at this location								
107	6	No peat recorded at this location								
108	6	No peat recorded at this location								
109	6	No peat recorded at this location								
110	4	No peat recorded at this location								
113	3	No peat recorded at this location								
114	3	No peat recorded at this location								
115	2	No peat recorded at this location								
116	3	No peat recorded at this location								
117	4	No peat recorded at this location								
118	4	No peat recorded at this location								
119	4	No peat recorded at this location								
120	4	No peat recorded at this location								
121	4	No peat recorded at this location								
122	4	No peat recorded at this location								
123	4	No peat recorded at this location								
124	4	No peat recorded at this location								
125	4	No peat recorded at this location								
126	3	No peat recorded at this location								
127	3	No peat recorded at this location								
128	3	4	10.0	10.0	0.1	25	1.0	1.1	**85.43**	**15.86**
129	4	No peat recorded at this location								
130	4	No peat recorded at this location								
131	4	No peat recorded at this location								
132	3	No peat recorded at this location								
133	2	No peat recorded at this location								
134	2	No peat recorded at this location								
135	3	No peat recorded at this location								
136	3	No peat recorded at this location								
137	3	No peat recorded at this location								
138	3	No peat recorded at this location								
139	3	No peat recorded at this location								
SUB1	2	No peat recorded at this location								
SUB2	2	No peat recorded at this location								
SUB3	2	No peat recorded at this location								
SUB4	2	No peat recorded at this location								
SC1-1	4	4	10.0	10.0	1.5	25	1.0	2.5	**10.50**	**8.97**
SC1-2	4	4	10.0	10.0	0.6	25	1.0	1.6	**16.25**	**10.26**
SC1-3	4	4	10.0	10.0	0.3	25	1.0	1.3	**25.83**	**11.09**
SC2	2	4	10.0	10.0	0.2	25	1.0	1.2	**70.70**	**22.91**
T1	2	4	10.0	10.0	3.1	25	1.0	4.1	**17.05**	**16.15**
T2	2	4	10.0	10.0	3.4	25	1.0	4.4	**16.73**	**15.96**
T3	2	4	10.0	10.0	3.4	25	1.0	4.4	**16.73**	**15.96**
T4	2	4	10.0	10.0	3.7	25	1.0	4.7	**16.45**	**15.79**
T5	2	4	10.0	10.0	1.2	25	1.0	2.2	**22.91**	**18.57**
T6	3	4	10.0	10.0	2.2	25	1.0	3.2	**12.38**	**11.29**
T7	3	4	10.0	10.0	0.1	25	1.0	1.1	**85.43**	**15.86**
T8	6	4	10.0	10.0	0.2	25	1.0	1.2	**23.68**	**7.64**
Met	3	4	10.0	10.0	0.5	25	1.0	1.5	**24.20**	**14.00**
Dep1-1	3	4	10.0	10.0	2.5	25	1.0	3.5	**11.96**	**11.08**
Dep1-2	2	4	10.0	10.0	1.5	25	1.0	2.5	**21.00**	**17.94**
Dep1-3	3	4	10.0	10.0	3	25	1.0	4.0	**11.45**	**10.81**
Dep1-4	3	4	10.0	10.0	2	25	1.0	3.0	**12.72**	**11.45**
Dep1-5	2	4	10.0	10.0	3.2	25	1.0	4.2	**16.94**	**16.08**
Dep1-6	3	4	10.0	10.0	3	25	1.0	4.0	**11.45**	**10.81**
								Minimum =	**1.80**	**2.96**
								Maximum =	**114.68**	**22.91**
								Average =	**19.41**	**12.11**

Notes:

(1) Assuming a bulk unit weight of peat of 10 (kN/m^3)
(2) Assuming a surcharge equivalent to fill depth of 1.0m.
(3) Slope inclination (β) based on site readings and contour survey plans of site.
(4) FoS is based on slope inclination and shear test results obtained from published data.
(5) Peat depths based on probes carried out by FT.
(6) For load conditions see Report text.
(7) Minimum acceptable factor of safety required of 1.3 for first-time failures based on BS: 6031:1981 Code of practice for Earthworks.
(8) SS: Superseded

Calculated FoS of Natural Peat Slopes for Cush Wind Farm - Undrained Analysis

Turbine No./Waypoint	Easting	Northing	Slope	Undrained shear strength	Bulk unit weight of Peat	Peat Depth	Surcharge Equivalent Placed Fill Depth (m)	Factor of Safety for Load Condition	
			β (deg)	c_u (kPa)	γ (kN/m^3)	(m)	Condition (2)	Condition (1)	Condition (2)
1	606401	708947	6	No peat recorded at this location					
2	606379	709045	4	No peat recorded at this location					
3	606350	709140	4	No peat recorded at this location					
4	606345	709238	2	No peat recorded at this location					
5	606370	709334	2	6	10	0.1	1.1	**172.03**	**15.64**
6	606374	709434	2	6	10	0.8	1.8	**21.50**	**9.56**
7	606377	709534	2	6	10	1.8	2.8	**9.56**	**6.14**
8	606381	709634	3	6	10	2	3.0	**5.74**	**3.83**
9	606361	709731	2	6	10	2.7	3.7	**6.37**	**4.65**
10	606329	709826	3	6	10	2.5	3.5	**4.59**	**3.28**
11	606320	709853	4	6	10	3.2	4.2	**2.69**	**2.05**
12	606388	709405	3	6	10	0.9	1.9	**12.76**	**6.04**
13	606481	709378	2	6	10	1	2.0	**17.20**	**8.60**
14	606581	709367	3	6	10	1.5	2.5	**7.65**	**4.59**
15	606680	709356	3	6	10	1.1	2.1	**10.44**	**5.47**
16	606779	709346	3	6	10	0.2	1.2	**57.40**	**9.57**
17	606877	709365	3	6	10	0.5	1.5	**22.96**	**7.65**
18	606966	709410	4	6	10	0.6	1.6	**14.37**	**5.39**
19	607040	709477	3	6	10	1	2.0	**11.48**	**5.74**
20	607092	709562	3	6	10	1.5	2.5	**7.65**	**4.59**
21	607136	709652	2	6	10	2.2	3.2	**7.82**	**5.38**
22	607156	709746	2	6	10	2.4	3.4	**7.17**	**5.06**
23	607139	709842	2	6	10	1.8	2.8	**9.56**	**6.14**
24	607151	709941	2	6	10	3.6	4.6	**4.78**	**3.74**
25	607163	710041	3	6	10	3.8	4.8	**3.02**	**2.39**
26	607079	710051	2	6	10	3.8	4.8	**4.53**	**3.58**
27	607038	710046	2	6	10	4	5.0	**4.30**	**3.44**
28	607165	710063	2	6	10	2.8	3.8	**6.14**	**4.53**
29	607265	710076	4	6	10	2.2	3.2	**3.92**	**2.69**
30	607365	710074	2	6	10	1.1	2.1	**15.64**	**8.19**
31	607460	710098	6	6	10	1.2	2.2	**4.81**	**2.62**
32	607510	710144	8	6	10	0.5	1.5	**8.71**	**2.90**
33	607504	710243	3	6	10	1.7	2.7	**6.75**	**4.25**
34	607513	710342	2	6	10	1.3	2.3	**13.23**	**7.48**
35	607520	710442	2	6	10	3.6	4.6	**4.78**	**3.74**
36	607440	710484	2	6	10	0.3	1.3	**57.34**	**13.23**
37	607342	710469	2	6	10	0.4	1.4	**43.01**	**12.29**
38	607242	710472	3	6	10	2.8	3.8	**4.10**	**3.02**
39	607144	710491	2	6	10	2.7	3.7	**6.37**	**4.65**
40	607046	710510	2	6	10	3	4.0	**5.73**	**4.30**
41	606946	710506	2	6	10	1.8	2.8	**9.56**	**6.14**
42	606850	710478	2	6	10	4	5.0	**4.30**	**3.44**
43	606774	710456	2	6	10	3.6	4.6	**4.78**	**3.74**
44	607469	710489	2	6	10	0.3	1.3	**57.34**	**13.23**
45	607424	710575	2	6	10	1	2.0	**17.20**	**8.60**
46	607394	710670	2	6	10	3.6	4.6	**4.78**	**3.74**
47	607364	710766	2	6	10	3.6	4.6	**4.78**	**3.74**
48	607360	710776	2	6	10	3.8	4.8	**4.53**	**3.58**
49	607525	710115	6	6	10	1	2.0	**5.77**	**2.89**
50	607608	710089	2	6	10	0.4	1.4	**43.01**	**12.29**
51	607707	710095	4	6	10	0.4	1.4	**21.56**	**6.16**
52	607777	710035	2	6	10	1.3	2.3	**13.23**	**7.48**
53	607834	709953	2	6	10	2.2	3.2	**7.82**	**5.38**
54	607842	709942	2	6	10	2.4	3.4	**7.17**	**5.06**
55	607739	710096	6	6	10	0.3	1.3	**19.24**	**4.44**
56	607834	710070	2	6	10	1.2	2.2	**14.34**	**7.82**
57	607918	710016	3	6	10	2	3.0	**5.74**	**3.83**
58	608005	710034	3	6	10	1.9	2.9	**6.04**	**3.96**
59	608025	710132	3	6	10	1.7	2.7	**6.75**	**4.25**
60	608041	710231	2	6	10	1.6	2.6	**10.75**	**6.62**
61	608035	710329	3	6	10	1.7	2.7	**6.75**	**4.25**
62	607979	710412	2	6	10	2	3.0	**8.60**	**5.73**
63	607924	710489	2	6	10	1.5	2.5	**11.47**	**6.88**
64	607942	710001	4	6	10	1.7	2.7	**5.07**	**3.19**
65	608028	709949	4	6	10	1.8	2.8	**4.79**	**3.08**
66	608114	709898	2	6	10	3.6	4.6	**4.78**	**3.74**
67	608192	709836	2	6	10	0.2	1.2	**86.01**	**14.34**
68	608252	709756	4	6	10	0.2	1.2	**43.11**	**7.19**
69	608283	709712	4	6	10	0.1	1.1	**86.22**	**7.84**
70	608132	709892	2	6	10	3.5	4.5	**4.92**	**3.82**
71	608193	709962	3	6	10	3	4.0	**3.83**	**2.87**
72	608219	710059	3	6	10	2.5	3.5	**4.59**	**3.28**
73	608263	710148	3	6	10	2	3.0	**5.74**	**3.83**
74	608357	710174	6	6	10	0.4	1.4	**14.43**	**4.12**
75	608449	710181	6	6	10	0.4	1.4	**14.43**	**4.12**
76	608265	710176	3	6	10	2	3.0	**5.74**	**3.83**
77	608273	710275	4	6	10	1.9	2.9	**4.54**	**2.97**
78	608301	710360	3	No peat recorded at this location					
79	608393	710319	2	No peat recorded at this location					
80	608486	710285	2	No peat recorded at this location					
81	608586	710278	3	6	10	0.1	1.1	**114.80**	**10.44**
82	608682	710253	3	6	10	0.1	1.1	**114.80**	**10.44**
83	608761	710211	3	6	10	0.2	1.2	**57.40**	**9.57**
84	608291	710377	4	6	10	1.9	2.9	**4.54**	**2.97**
85	608353	710456	2	6	10	1.2	2.2	**14.34**	**7.82**
86	608417	710532	3	6	10	1.9	2.9	**6.04**	**3.96**
87	608480	710610	3	6	10	3.9	4.9	**2.94**	**2.34**
88	608462	710703	3	6	10	3.4	4.4	**3.38**	**2.61**
89	608416	710792	3	6	10	3.5	4.5	**3.28**	**2.55**
90	608370	710881	4	6	10	3	4.0	**2.87**	**2.16**
91	608325	710970	3	6	10	4.5	5.5	**2.55**	**2.09**
92	608291	711037	2	6	10	4.3	5.3	**4.00**	**3.25**
93	608509	710629	3	6	10	3.8	4.8	**3.02**	**2.39**
94	608593	710683	4	6	10	4.5	5.5	**1.92**	**1.57**
95	608676	710739	2	6	10	4	5.0	**4.30**	**3.44**
96	608739	710816	3	6	10	4.3	5.3	**2.67**	**2.17**
97	608801	710894	2	6	10	4.6	5.6	**3.74**	**3.07**
98	608863	710973	3	6	10	5	6.0	**2.30**	**1.91**
99	608925	711051	3	6	10	4.4	5.4	**2.61**	**2.13**

Calculated FoS of Natural Peat Slopes for Cush Wind Farm - Undrained Analysis

Turbine No./Waypoint	Easting	Northing	Slope	Undrained shear strength	Bulk unit weight of Peat	Peat Depth	Surcharge Equivalent Placed Fill Depth (m)	Factor of Safety for Load Condition	
			β (deg)	c_u (kPa)	γ (kN/m^3)	(m)	Condition (2)	Condition (1)	Condition (2)
100	608967	711103	3	6	10	5	6.0	**2.30**	**1.91**
101	606380	709025	4	No peat recorded at this location					
102	606375	708943	6	No peat recorded at this location					
103	606276	708926	8	No peat recorded at this location					
104	606188	708968	10	No peat recorded at this location					
105	606105	709024	8	No peat recorded at this location					
106	606012	709059	8	No peat recorded at this location					
107	605915	709084	6	No peat recorded at this location					
108	605828	709133	6	No peat recorded at this location					
109	605767	709206	6	No peat recorded at this location					
110	605713	709290	4	No peat recorded at this location					
113	605484	709157	3	No peat recorded at this location					
114	605391	709124	3	No peat recorded at this location					
115	605305	709073	2	No peat recorded at this location					
116	605212	709048	3	No peat recorded at this location					
117	605149	709029	4	No peat recorded at this location					
118	605178	708933	4	No peat recorded at this location					
119	605206	708837	4	No peat recorded at this location					
120	605235	708741	4	No peat recorded at this location					
121	605264	708646	4	No peat recorded at this location					
122	605293	708550	4	No peat recorded at this location					
123	605321	708454	4	No peat recorded at this location					
124	605350	708358	4	No peat recorded at this location					
125	605379	708263	4	No peat recorded at this location					
126	605408	708167	3	No peat recorded at this location					
127	605437	708071	3	No peat recorded at this location					
128	605464	707975	3	6	10	0.1	1.1	**114.80**	**10.44**
129	605377	707960	4	No peat recorded at this location					
130	605284	707994	4	No peat recorded at this location					
131	605195	708040	4	No peat recorded at this location					
132	605108	708089	3	No peat recorded at this location					
133	605023	708137	2	No peat recorded at this location					
134	608364	709790	2	No peat recorded at this location					
135	608455	709748	3	No peat recorded at this location					
136	608504	709693	3	No peat recorded at this location					
137	608452	709607	3	No peat recorded at this location					
138	608426	709528	3	No peat recorded at this location					
139	608462	709503	3	No peat recorded at this location					
SUB1	604937	708195	2	No peat recorded at this location					
SUB2	604876	708273	2	No peat recorded at this location					
SUB3	604802	708316	2	No peat recorded at this location					
SUB4	604761	708326	2	No peat recorded at this location					
SC1-1	606271	709149	4	6	10	1.5	2.5	**5.75**	**3.45**
SC1-2	606275	709014	4	6	10	0.6	1.6	**14.37**	**5.39**
SC1-3	606323	709075	4	6	10	0.3	1.3	**28.74**	**6.63**
SC2	608374	710304	4	6	10	0.2	1.2	**43.11**	**7.19**
T1	606797	710446	2	6	10	3.1	4.1	**5.55**	**4.20**
T2	606312	709829	2	6	10	3.4	4.4	**5.06**	**3.91**
T3	607351	710753	2	6	10	3.4	4.4	**5.06**	**3.91**
T4	607060	710033	2	6	10	3.7	4.7	**4.65**	**3.66**
T5	607922	710465	2	6	10	1.2	2.2	**14.34**	**7.82**
T6	607844	709967	3	6	10	2.2	3.2	**5.22**	**3.59**
T7	608286	709735	3	6	10	0.1	1.1	**114.80**	**10.44**
T8	608427	710195	6	6	10	0.2	1.2	**28.86**	**4.81**
Met	608483	709506	3	6	10	0.5	1.5	**22.96**	**7.65**
Dep1-1	606684	710675	3	6	10	2.5	3.5	**4.59**	**3.28**
Dep1-2	606905	710585	2	6	10	1.5	2.5	**11.47**	**6.88**
Dep1-3	606913	710816	3	6	10	3	4.0	**3.83**	**2.87**
Dep1-4	607128	710683	3	6	10	2	3.0	**5.74**	**3.83**
Dep1-5	607111	710920	2	6	10	3.2	4.2	**5.38**	**4.10**
Dep1-6	607315	710922	3	6	10	3	4.0	**3.83**	**2.87**
							Minimum =	**1.92**	**1.57**
							Maximum =	**172.03**	**15.64**
							Average =	**17.63**	**5.25**

Notes:

(1) Assuming a bulk unit weight for peat of 10kN/m^3

(2) Assuming a surcharge equivalent to fill depth of 1m of peat i.e. 10kPa.

(3) Slope inclination (β) based on site readings and site contour plans.

(4) A lower bound undrained shear strength, cu for the peat of 6kPa was selected for the assessment. It should be noted that a cu of 6kPa for the peat is considered a conservative value for the analysis and is not representative of all peat present across the site. In reality the peat has a significantly higher undrained strength.

(5) Peat depths based on probes carried out by FT.

(6) For load conditions see report text.

(7) SS: Superseded

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APPENDIX D

Methodology for Peat Stability Risk Assessment

Methodology for Peat Stability Risk Assessment

A peat stability risk assessment was carried out for each of the main infrastructure elements at the proposed wind farm development. This approach takes into account guidelines for geotechnical/peat stability risk assessments as given in PLHRAG (2nd Edition, 2017) and MacCulloch (2005). The degree of risk is determined as a Risk Rating (R), which is the product of probability (P) and impact (I). How these factors are determined and applied in the analysis is described below.

The main approaches for assessing peat stability include the following:

a) Geomorphological
b) Qualitative (judgement)
c) Index/Probabilistic (probability)
d) Deterministic (factor of safety)

Approaches a) to c) listed above would be considered subjective and do not provide a definitive indication of stability; in addition, a high level of judgement/experience is required which makes it difficult to relate the findings to real conditions. FT apply a more objective approach, the deterministic approach. As part of FT's deterministic approach, a qualitative risk assessment is also carried out taking into account qualitative factors, which cannot necessarily be quantified.

Probability

The likelihood of a peat failure occurring was assessed based on the results of both the quantitative results of stability calculations (deterministic approach using factors of safety) and the assessment of the severity of several qualitative factors which cannot be reasonably included in a stability calculation but nevertheless may affect the occurrence of peat instability.

The qualitative factors used in the risk assessment are outlined in Table A and have been compiled based on FT's experience of assessments and construction in peat land sites and peat failures throughout Ireland and the UK.

Table A: Qualitative Factors used to Assess Potential for Peat Failure

Qualitative Factor	Type of Feature/Indicator for each Qualitative Factor [(1)]	Explanation/Description of Qualitative Factor
Evidence of sub peat water flow	No	Based on site walkover observations. Sub peat water flow generally occurs in the form of natural piping at the base of peat. Where there is a constriction or blockage in natural pipes a build-up of water can occur at the base of the peat causing a reduction in effective stress at the base of the peat resulting in failure; this is particularly critical during periods of intense rainfall.
	Possibly	
	Probably	
	Yes	
	Dry	

Qualitative Factor	Type of Feature/Indicator for each Qualitative Factor [1]	Explanation/Description of Qualitative Factor
Evidence of surface water flow	Localised/Flowing in drains	Based on site walkover observations. The presence of surface water flow indicates if peat in an area is well drained or saturated and if any additional loading from the ponding of surface water onto the peat is likely.
	Ponded in drains	
	Springs/surface water	
Evidence of previous failures/slips	No	Based on site walkover observations. The presence of clustering of relict failures may indicate that particular pre-existing site conditions predispose a site to failure.
	In general area	
	On site	
	Within 500m of location	
Type of vegetation	Grass/Crops	Based on site walkover observations. The type of vegetation present indicates if peat in an area is well drained, saturated, etc. Vegetation that indicates wetter ground may also indicate softer underlying peat deposits.
	Improved Grass/Dry Heather	
	Wet Grassland/Juncus (Rushes)	
	Wetlands Sphagnum (Peat moss)	
General slope characteristics upslope/downslope from infrastructure location	Concave	Based on site walkover observations. Slope morphology in the area of the infrastructure location is an important factor. A number of recorded peat failures have occurred in close proximity to a convex break in slope.
	Planar to concave	
	Planar to convex	
	Convex	
Evidence of very soft/soft clay at base of peat	No	Based on inspection of exposures in general area from site walkover. Several reported peat failures identify the presence of a weak layer at the base of the peat along which shear failure has occurred.
	Yes	
Evidence of mechanically cut peat	No	Based on site walkover observations. Mechanically cut peat typically cut using a 'sausage' machine to extract peat for harvesting. Areas which have been cut in this manner have been linked to peat instability. The mechanical cuts can notably reduce the intrinsic strength of the peat and also allow ingress of rainfall/surface water.
	Yes	
Evidence of quaking or buoyant peat	No	Based on site walkover observations. Quaking/buoyant peat is indicative of highly

Qualitative Factor	Type of Feature/Indicator for each Qualitative Factor (1)	Explanation/Description of Qualitative Factor
	Yes	saturated peat, which would generally be considered to have a low strength. Quaking peat is a feature on sites that have been previously linked with peat instability.
Evidence of bog pools	No	Based on site walkover observations. Bog pools are generally an indicator of areas of weak, saturated peat. Commonly where there are open areas of water within peat these can be interconnected, with the result that there may be sub-surface bodies of water. The presence of bog pools has been previously linked with peat instability.
	Yes	
Other	Varies	In addition to the above features/ indicators and based on site recordings the following are some of the features which may be identified: Excessively deep peat, weak peat, overly steep slope angles, etc.

Note (1) The list of features/indicators for each qualitative factor are given in increasing order of probability of leading to peat instability/failure.

It should be noted that the presence of one of the qualitative factors alone from Table A is unlikely to lead to peat instability/failure. Peat instability/failure at a site is generally the combination of a number of these factors occurring at the same time at a particular location. The probability rating assigned to the quantitative and qualitative factors is judged on a 5-point scale from 1 (indicating negligible or no probability of failure) to 5 (indicating a very likely failure), as outlined in Table B:

Table B: Probability Scale

Scale	Factor of Safety	Probability
1	1.30 or greater	Negligible/None
2	1.29 to 1.20	Unlikely
3	1.19 to 1.11	Likely
4	1.01 to 1.10	Probable
5	≤1.0	Very Likely

Scale	Likelihood of Qualitative Factor leading to Peat Failure	Probability of Failure
1	Negligible/None	Least
2	Unlikely	
3	Probable	
4	Likely	
5	Very Likely	Greatest

Impact

The severity of the risk is also assessed qualitatively in terms of impact. The impact of a peat failure on the environment within and beyond the immediate wind farm site is assessed based on the potential travel distance of a peat failure. Where a peat failure enters a watercourse, it can travel a considerable distance downstream. Therefore, the proximity of a potential peat failure to a drainage course is a significant indicator of the likely potential impact.

The risk is determined based on the combination of hazard and impact. A qualitative scale has been derived for the impact of the hazard based on distance of infrastructure element to a watercourse (Table C).

The location of watercourses is based on topographic maps and supplemented by site observations from walkover survey. Note that not all watercourses are shown on maps.

Table C: Impact Scale

Scale	Criteria	Impact
1	Proposed infrastructure element greater than 150m of watercourse	Negligible/None
2	Proposed infrastructure element within 150 to 101m of watercourse	Low
3	Proposed infrastructure element within 100 to 51m of watercourse	Medium
4	Proposed infrastructure element within 50 m of watercourse	High
5	Proposed infrastructure element within 50 m of watercourse, in an environmentally sensitive area	Extremely High

Risk Rating

The degree of risk is determined as the product of probability (P) and impact (I), which gives the Risk Rating (R) as follows:

The Risk Rating is calculated from: $R = P \times I$

Due to the 5-point scales used to assess Probability and Impact, the Risk Rating can range from 1 to 25 as shown in Table D.

Table D: Qualitative Risk Rating

	Probability					
Impact		1	2	3	4	5
	5	5	10	15	20	25
	4	4	8	12	16	20
	3	3	6	9	12	15
	2	2	4	6	8	10
	1	1	2	3	4	5

Risk Rating & Control Measures	
17 to 25	High: avoid working in area or significant control measures required
11 to 16	Medium: notable control measures required
5 to 10	Low: only routine control measures required
1 to 4	Negligible: none or only routine control measures required

The risk rating is calculated individually for each contributory factor. Control measures are required to reduce the risk to at least a 'Low' risk rating. The control measures in response to the qualitative risk ratings are included in the peat stability risk registers for each main infrastructure element in Appendix B.

The risk rating is calculated individually for each contributory factor. Control measures are required to reduce the risk to at least a 'Low' risk rating.

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